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(54) **Multiplex signal processing apparatus.**

(57) Disclosed are multiplex signal processing apparatuses in a signal transmitting and receiving system. The apparatus at the transmitting side comprises: a first amplitude-modulator for modulating a first carrier by a main signal to obtain a vestigial side band, amplitude-modulated main signal; a second amplitude-modulator for modulating a second carrier which is same in frequency to and different in phase by 90° from the first carrier by a multiplex signal to obtain a double side band, amplitude-modulated multiplex signal; an inverse Nyquist filter for filtering this signal to obtain a vestigial side band, amplitude-modulated multiplex signal; and an adder for adding the vestigial side band, amplitude-modulated main and multiplex signals to obtain a multiplexed signal. The apparatus at the receiving side comprises: a Nyquist filter for filtering the multiplexed signal; a carrier regenerator for regenerating the first and second carriers from the multiplexed signal; a main signal detector for detecting the main signal from the multiplexed signal passed through the Nyquist filter by using the first carrier; a filter for removing quadrature distortion from the multiplexed signal; and a multiplex signal detector for detecting the multiplex signal from the multiplexed signal passed through the filter by using the second carrier.

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This invention, when applied to the television system, provides a large quantity of additional information while keeping compativility with the conventional television system.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an apparatus for multiplexing a specific signal with an amplitude-modulated signal, transmitting and receiving the multiplexed signal, and extracting the specific signal from the multiplexed signal.

2. Description of the Prior Art

In Japan, more than 25 years have passed since the color television broadcasting of the current NTSC (National Television System Committee) system began in 1960. In this period, to answer the requests for finer definition and higher performance television receiver, various new television systems have been proposed. At the same time, the contents of the programs presented to the viewers have been changed from the mere studio programs or location programs to programs providing images of higher picture quality and higher realistic feeling such as cinema-size movies.

The current broadcasting is specified with 525 scanning lines, 2:1 interlace scanning, luminance signal horizontal bandwidth of 4.2 MHz, and aspect ratio of 4:3 (see, for example, Broadcasting Technology Series, Color Television, ed. by Japan Broadcasting Corporation, Japan Broadcasting Corporation Pub., 1961). In this background, several television signal composition methods aiming at compatibility with the current broadcasting system and enhancement of horizontal resolution have been proposed. One of such examples is disclosed in the Japanese Laid-Open Patent No. 59-171387. Considering the NTSC television signal expressed on a two-dimensional plane of temporal frequency f_1 and vertical frequency f_2, chrominance signals C are present in the second and fourth quadrants due to the phase relation with the chrominance subcarrier fsc. The example uses the vacant first and third quadrants for multiplexing the high frequency components of luminance signal. The chrominance signal and the multiplex high frequency components are separated and reproduced at the receiving end, thereby enhancing the horizontal resolution.

In the current television broadcast, as clear from the description above, the band of signals is limited by the standard, and it is not easy to add some new information in quantity. For example, methods to enhance the horizontal resolution are proposed, but many problems are left unsolved from the viewpoint of the compatibility with the current television broadcasting and deterioration of demodulation characteristics of high frequency components in a moving picture. Besides, from the standpoint of effective use of the radio wave resources, the transmission band cannot be extended as an easy solution.

The present invention provides an apparatus for transmitting a wide aspect ratio television signal corresponding to an image displayed on a television screen having a wider aspect ratio than 4:3, comprising:

a first time-axis expanding means for expanding on time-axis a first part of said wide aspect ratio television signal to obtain a first television signal, said first part corresponding to a part having the aspect ratio of 4:3 of said wide aspect ratio television signal;

a second time-axis expanding means for expanding on time-axis a second part which is the remaining part of said wide aspect ratio television signal to obtain a second television signal;

a frequency-axis multiplexing means for multiplexing said first and second television signals on frequency axis to obtain a multiplexed television signal; and

a means for transmitting said multiplexed television signal.

The present invention also provides an apparatus for receiving a multiplexed television signal transmitted from an apparatus as outlined above, comprising:

a means for receiving said multiplexed television signal;

a signal separating means for separating the received multiplexed television signal into said first and second television signals;

a first time-axis compressing means for compressing on time axis said first television signal to obtain said first part of said wide aspect ratio television signal;

a second time-axis compressing means for compressing on time axis said second television signal to obtain said second part of said wide aspect ratio television signal; and

a means for composing said wide aspect ratio television signal from said first and second parts.

It is a primary object of this invention to present a multiplex signal processing apparatus for multiplex transmission of a large quantity of information in a defined band.

By this constitution, in, for example, the television broadcasting, it is possible to obtain not only the conventional television broadcasting images but also additional information at the receiver which is used to provide a wider aspect ratio than 4:3, by generating a television signal capable of multiplex transmission of other information within the standard band of the existing television broadcasting. At the same time, when received the multiplexed signal by an existing television receiver, there is almost no interference by the signal carrying the additional information, hereinafter referred to as the multiplex signal, and compatibility with the existing television receivers can be maintained. Further, since multiplex transmission of the additional information is possible in a band determined by the standard, it is very advantageous also from the viewpoint of effective use of radio wave resources.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 2, Fig. 5(a), Fig. 6(a), Fig. 9(a), Fig. 12(a), Fig. 18, Fig. 24, Fig. 30 are block diagrams each showing a multiplex signal processor at the transmission side embodying this invention;
Fig. 4(c), Fig. 5(b), Fig. 6(b), Fig. 9(b), Fig. 12(b), Fig. 25, Fig. 35 are block diagrams each showing a multiplex signal processor at the reception side embodying this invention;
Fig. 1, Fig. 7, Fig. 10, Fig. 23 are spectral diagrams showing the processing method of the multiplex signal processor at the transmission side according to this invention;
Fig. 4(a), Fig. 8, Fig. 11 are spectral diagrams showing the processing method of the multiplex signal processor at the reception side according to this invention;
Fig. 4(b) is a vector diagram to explain the principle of the multiplex signal processor at the reception side according to this invention;
Fig. 3(a), (b), (c) are respectively block diagram, spectral diagram and vector diagram showing a conventional television receiver;
Fig. 13(a) is an internal circuit composition of a signal generator 125 in Fig. 12(a);
Fig. 13(b) shows an example of discriminating signal;
Fig. 14 is an internal circuit composition of a signal separator 131 in Fig. 12(b);
Fig. 15 is an internal circuit composition of a signal selector 137 in Fig. 12(b);
Fig. 16 is an example of display screen of existing television and a time-axis expression of composite video signal;
Fig. 17 is an example of display screen at aspect ratio of 5:3 and a time-axis expression of composite video signal;
Fig. 19 is a picture composition at different aspect ratio;
Fig. 20 is a signal waveform diagram showing the signal processing step in Fig. 18;
Fig. 21 is a spectral diagram showing the signal processing step in Fig. 18;
Fig. 22 is a diagram showing the blanking period of television signal;
Fig. 26 is a block diagram of transmission device according to this invention;
Fig. 27 shows waveforms of reference signal generated in reference signal generator in Fig. 26 and Fig. 28;
Fig. 28 is a circuit composition of an example of ghost reduction device of Fig. 26;
Fig. 29 is a circuit composition of an example of transversal filter of Fig. 28;
Fig. 31 is a circuit composition of an example of video high frequency range auxiliary signal circuit of Fig. 30;
Fig. 32 is a circuit composition of an example of wide aspect video auxiliary circuit of Fig. 30;
Fig. 33 is a waveform diagram to explain the operation of wide aspect video auxiliary circuit of Fig. 30;
Fig. 34 is a circuit composition of an example of scramble processor of Fig. 30;
Fig. 36 is a circuit composition of an example of video high frequency range addition circuit of Fig. 35;
Fig. 37 is a circuit composition of an example of wide aspect video addition circuit of Fig. 35;
Fig. 38 is a circuit composition of an example of scramble demodulator of Fig. 35;
Fig. 39 is a circuit composition of an example of small screen video addition circuit of Fig. 35; and
Fig. 40 is a waveform diagram to explain the operation of small screen video addition circuit of Fig. 35.
Fig. 41 is a block diagram showing a television multiplex signal processor at the transmission side according to this invention;
Fig. 42 is a circuit composition of an example of multiplex signal processing circuit 610 in Fig. 41;
Fig. 43 is a block diagram showing a television multiplex signal processor at the reception side according to this invention; and
Fig. 44 is a circuit composition of an example of multiplex signal regenerating circuit 701 in Fig. 43.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 is a spectral diagram to show the television signal processing method at the transmission side according to an embodiment of this invention. More specifically, Fig. 1(a) is a spectral diagram of vestigial side band, amplitude-modulated television signal in the NTSC television system, in which the lower side band of video carrier P_1 is the vestigial side band. In this case, the signal may be any television signal amplitude-modulated in the vestigial side band, and it is not limited to the NTSC television signal. Fig. 1(b) is a signal which is obtained by amplitude-modulating a vestigial side band of a carrier P_2 which is same in frequency as and different in phase by 90° from the video carrier P_1 by a multiplex signal different from the television signal in Fig. 1(a). Preferably the carrier P_2 is removed in the blanking period. When the signal in Fig. 1(b) is multiplexed with the television signal in Fig. 1(a), the result is as shown in Fig. 1(c). The multiplex signal may be either analog signal or digital signal.

Fig. 2 is a block diagram showing a television multiplex signal processor at the transmission side as one of the embodiments of this invention, in which denoted by numeral 601 is a main signal generator, 1 is a main signal input terminal, 2 is an amplitude modulator, 3 is a VSB filter, 4 is an oscillator, 5 is a phase shifter, 602 is a multiplex signal generator, 6 is a multiplex signal input terminal, 7 is an amplitude modulator, 8 is an inverse Nyquist filter, 9 is an adder, 10 is a composite signal output terminal, 58 is a transmitter, and 59 is an antenna. Numeral 11 denotes a multiplex signal superposing circuit. By a main signal generated by the original signal generator 601, for example, a video base band signal, a carrier P_1 generated by the oscillator 4 is amplitude-modulated at the amplitude modulator 2. The obtained modulated signal is limited in the band by the VSB filter 3 to become a vestigial side band signal, which is fed to the adder 9. The VSB filter 3 is a filter to transform a double side band signal into a vestigial side band signal. The carrier P_1 from the oscillator 4 is shifted at phase by 90° at the phase shifter 5 to be a carrier P_2. By a multiplex signal generated in the multiplex signal generator 602, the carrier P_2 is amplitude-modulated in double side band at the amplitude modulator 7, and preferably in the blanking period the carrier is removed. The phase shift direction of the phase shifter 5 may be either fixed or varied at intervals of horizontal scanning period, field or frame. The modulated multiplex signal is limited in the band by the inverse Nyquist filter 8, and then fed to the adder 9.

The amplitude frequency characteristic of the inverse nyquist filter 8 is, as mentioned later, to possess a property symmetrical to the amplitude frequency characteristic immediately before video detection at the receiver with respect to the video carrier. The output of the adder 9 is a composite signal. That is, the modulated multiplex signal is superposed on the modulated video base band signal at the adder 9 to produce the composite signal. The composite signal is transmitted from the transmitter 58 with the antenna 59, but the transmission path is not limited to the wireless system. In this example, the composite signal is obtained by adding the outputs of the VSB filter 3 and the inverse Nyquist filter 8, but it is also possible to feed the sum of the outputs of the amplitude modulator 2 and the inverse Nyquist filter 8 into the VSB filter 3 to obtain the composite signal.

On the other hand, a television multiplex signal processor at the reception side as one of the embodiments of this invention is as follows. The following example refers to terrestrial broadcasting of NTSC television system, but it is not intended as limitation. Fig. 3(a) is a block diagram of an existing television receiver for video synchronous detection, in which denoted by numeral 21 is an antenna, 22 is a tuner, 23 is a Nyquist filter, 24 is a video detector, 25 is a carrier regenerator, and 26 is a main signal output terminal. The signal transmitted from the transmission side is received by the antenna 21, converted in frequency to intermediate frequency band by the tuner 22, and limited in the band by the Nyquist filter 23. The band-limited signal is fed into the video detector 24 and the carrier regenerator 25. In the carrier regenerator 25, a video carrier I_1 for synchronous detection is regenerated. The band-limited signal is synchronously detected by the carrier I_1 at the video detector 24, and becomes the main signal, that is, the video base band signal. The frequency characteristic of the Nyquist filter 23 is as follows. Referring to Fig. 3(b) which shows the frequency characteristic of the Nyquist filter 23, the amplitude is attenuated by 6 dB at the video carrier I_1, and the Nyquist filter characteristic possesses nearly an odd-symmetrical amplitude property with respect to the video carrier I_1.

On the other hand, as shown in Fig. 1(b), when the multiplex signal is limited in band by the filter in the transmitter having an inverse characteristic to the frequency characteristic of the Nyquist filter in the receiver, the multiplex signal components in the shaded area of Fig. 3(b) is nearly double side band. When this is expressed by a vector diagram, it becomes as shown in Fig. 3(c), in which I_1 is the video carrier of the main signal, that is, the video base band signal, and I_2 is the carrier of the multiplex signal which carrier is same in frequency as but different in phase by 90° from I_1. The video base band signal is a vestigial side band with respect to the carrier I_1, so that the upper and lower side bands are vector a_U and vector a_L,

respectively, which are vector a_1 and vector a_2, respectively, when decomposed into orthogonal vectors. Since the multiplex signal is nearly double side band, supposing the upper and lower side bands to be vector b_U and vector v_L, respectively, their synthetic vector is b_2, which is only the component to intersect with vector I_1 orthogonally. That is, when the main signal is synchronously detected by the carrier I_1, quadrature distortion due to vector a_2, vector b_2, components does not occur. Thus, the impairment by the multiplex signal to the existing television receiver performing video synchronous detection does not occur, in principle.

Next, detection of multiplex signal at the reception side is described below. The signal of video intermediate frequency band which is the output of the tuner is limited in band by a band-pass filter, as shown in Fig. 4(a), so that the main signal, that is, the video base band signal becomes double side band. Its vector expression is shown in Fig. 4(b). Since the multiplex signal is vestigial side band with respect to the carrier I_2, the upper and lower side bands are vector b_U and vector b_L, respectively, which become vector b_1 and vector b_2, respectively, when decomposed into orthogonal vectors. At the same time, since the video base band signal is made nearly double side band by the function of the band-pass filter, supposing the upper and lower side bands to be vector a_U and vector a_L, respectively, their synthetic vector is a_1, which is only the component intersecting orthogonally with the vector I_2. That is, when the multiplex signal is synchronously detected by the carrier I_2, quadrature distortion due to vector a_1, vector b_1 components does not occur. Thus, only the multiplex signal components can be demodulated.

Fig. 4(c) shows an example of television multiplex signal processor for demodulating also the multiplex signal, in which denoted by numeral 31 is an antenna, 32 is a tuner, 33 is a Nyquist filter, 34 is a video detector, 35 is a carrier regenerator, 36 is an original signal output terminal, 37 is a band-pass filter, 38 is a phase shifter, 39 is a multiplex signal detector, 40 is a multiplex signal output terminal, 603 is a main signal processor, and 604 is a multiplex signal processor. Numeral 41 denotes a multiplex signal separator. The multiplexed signal transmitted from the transmission side is received by the antenna 31, converted in frequency into intermediate frequency band by the tuner 32, and limited in the band by the Nyquist filter 33. The band-limited signal is supplied into the video detector 34 and the carrier regenerator 35. In the carrier regenerator 35, a video carrier I_1 for synchronous detection is regenerated. The band-limited signal is detected by the carrier I_1 in the video detector 34, and becomes the main signal, that is, the video base band signal. The main signal is converted into, for example, R, G, B signals by the main signal processor 603, and displayed on a screen 1000.

The output of the tuner 32 is band-limited also as shown in Fig. 4(a) by the band-pass filter 37. By a carrier I_2 obtained by 90° phase shifting the carrier I_1 by the phase shifter 38 (that is, by the carrier I_2 in the same phase as the carrier for multiplex signal modulation used at the transmission side), the band-limited signal is synchronously detected in the multiplex signal detector 39, and becomes the multiplex signal. The multiplex signal is subjected to the reverse processing to the processing by the multiplex signal generator at the transmission side, in the multiplex signal regenerator 604. Each of the video detector 34 and the multiplex signal detector 39 is a detector for synchronous detection of an amplitude-modulated signal.

As described above, in the existing receiver, since the multiplex signal is nearly canceled by the synchronous detection by the video carrier I_1, the main signal is not interfered by the multiplex signal. Further, in the receiver capable of demodulating the multiplex signal, not only the main signal, that is, the video base band signal is obtained in the same way as above, but also the multiplex signal can be also obtained without quadrature distortion by filtering and synchronous detection by the carrier I_2. This is not limited to the NTSC television system, and can be applied to any system as far as the signal is amplitude-modulated in the vestigial side band.

Fig. 5(a) is a block diagram showing a television multiplex signal processor at the transmission side for multiplexing the high frequency components of luminance signal as one of the embodiments of this invention, in which denoted by numeral 51 are R, G, B input terminals, 52 is a matrix circuit, 53 is a chrominance modulator, 54 is a first filter, 55 is a second filter, 57 is a frequency converter, 56 is an adder, 11 is a multiplex signal superposing circuit, 1 is a main signal input terminal, 6 is a multiplex signal input terminal, 10 is a composite signal output terminal, 58 is a transmitter, and 59 is an antenna. R, G, B signals from a video camera or the like are supplied into the matrix circuit 52 to be converted into luminance signal Y and chrominance difference signals I and Q. The chrominance difference signals I and Q are modulated in the chrominance modulator 43 to become a carrier chrominance signal, which is fed into the adder 56. The luminance signal Y is fed into the first filter 54 and the second filter 55. The high frequency components of the luminance signal Y limited in band by the second filter 55 are converted into low frequency range by the frequency converter 57. The output of the first filter 54 is added with the carrier chrominance signal in the adder 56. The output of the adder 56 is fed through the main signal input terminal

1 into the multiplex signal superposing circuit 11. The output of the frequency converter 57 is fed through the multiplex signal input terminal 6 into the multiplex signal superposing circuit 11. The output of the multiplex signal superposing circuit 11 is a composite television signal having high frequency components of the luminance signal superposed on the video base band signal which is the main signal. The composite television signal is fed through the composite signal output terminal 10 into the transmitter 58, and is transmitted from the antenna 59. Here, the first filter is a low-pass filter passing, for example, 4.2 MHz or lower, and the second filter is a high-pass filter passing, for example, 4.2 MHz or higher or a band-pass filter passing between, for example, 4.2 and 5.2 MHz.

Fig. 5(b) is a block diagram showing a television multiplex signal processor at the reception side for reproducing the high frequency components of the luminance signal as one of the embodiments of this invention, in which denoted by numeral 41 is a multiplex signal separator, 36 is a main signal output terminal, 40 is a multiple signal output terminal, 61 is a luminance-chrominance separation circuit, 62 is a frequency converter, 63 is an adder 64 is a chrominance demodulator, 65 is a matrix circuit, and 66 are R, G, B output terminals, As stated above, the main signal, that is, the video base band signal is outputted from the multiplex signal separator 41 through the main signal output terminal 36, and is fed into the luminance-chrominance separation circuit 61. The multiplex signal is outputted from the multiplex separator 41 through the multiplex signal output terminal 40, and is fed into the frequency converter 62. The video base band signal is separated into the luminance signal and the carrier chrominance signal by the luminance-chrominance separation circuit 61. The separated carrier the chrominance signal is demodulated into the chrominance difference signals I and Q in the chrominance demodulator 64, and they are fed into the matrix circuit 65. The demodulated multiplex signal from the separator 41, that is, the high frequency components of the luminance signal is converted into the original frequency band by the frequency converter 62, and is added with the low frequency component of the luminance signal separated by the luminance-chrominance separation circuit 61 in the adder 63, and the added result is fed into the matrix circuit 65. The outputs of the matrix circuit 65 are R, G, B signals, which are supplied, for example, into a CRT 1000. In this way, the high frequency components of the luminance signal can be transmitted as the multiplex signal and demodulated, so that the horizontal resolution of luminance can be enhanced.

Fig. 6(a) is a block diagram showing a television multiplex signal processor at the transmission side for multiplexing the high frequency components of luminance signal as another embodiment of this invention. Fig. 7 is a explanatory diagram showing the signal waveforms at the corresponding parts in Fig. 6(a). Fig. 6-(b) is a block diagram showing a television multiplex signal processor at the reception side for reproducing the high frequency components of the luminance signal as another embodiment of this invention. Fig. 8 is a explanatory diagram showing the signal waveforms at the corresponding parts in Fig. 6(b).

First the signal synthesizing method at the transmission side shown in Fig. 6(a) is explained. A luminance signal of wide band (for example: 0 to 6.6 MHz) is separated into three frequency bands YL, YH1, YH2 by a frequency separator 91, in which YL is a low frequency luminance signal of 0 to 4.2 MHz, YH1 is a first high frequency luminance signal of 4.2 to 5.4 MHz, and YH2 is a second high frequency luminance signal of 5.4 to 6.6 MHz. On the other hand, chrominance difference signals I and Q are subjected to quadrature modulation by a quadrature modulator 92 to be a carrier chrominance signal in the same manner as in the ordinary NTSC system. The thus obtained carrier chrominance signal is added with the low frequency luminance signal YL in an adder 95. The spectrum of the added result is shown in Fig. 7-(g), which is similar to an ordinary NTSC signal. The second luminance signal YH2 (Fig. 7(d)) from 5.4 MHz to 6.6 MHz is multiplied by a signal of 1.2 MHz to be converted into frequency a signal of 4.2 MHz to 5.4 MHz (Fig. 7(e)) by a frequency converter 93. This 1.2 MHz signal may be selected at 1/3 of the subcarrier of the chrominance signal, and its phase information may be transmitted separately. This luminance signal converted into the lower frequency band is added with the first high frequency luminance signal YH1 in an adder 94 (Fig. 7(f)), and the resultant luminance signal is multiplied by a signal cos ω cc t of about 4.2 MHz in a frequency converter 96 to be converted into further low frequency band (Fig. 7(h)). The reference phase of the signal cos ω cc t for frequency conversion is transmitted in multiplexed form, for example, in the vertical blanking period. The composite luminance signal converted into the further low frequency and the composite video signal of 4.2 MHz or less which is compatible with the ordinary NTSC signal are subjected to quadrature modulation by amplitude modulators 7 and 2 using of video carriers sin ωvc t and cos ωvc t, respectively. At this time, when the multiplex signal of bandwidth of 1 MHz modulated by the amplitude modulator 7 is preliminarily suppressed in the direct-current component, the carrier suppression modulation is achieved as shown in Fig. 7(m), which is very convenient as stated later. This signal passes through an inverse Nyquist filter 8 having the characteristic as shown in Fig. 7(m). The video signal which is the main signal passes through a VSB filter 3 as shown in Fig. 7(l). The outputs of the filters 8 and 3 are synthesized in a synthesizer 97 to become a signal as shown in Fig. 7(n). This synthetic signal, as

compared with the ordinary NTSC video signal amplitude-modulated in the vestigial side band, has a multiplex signal of about 1 MHz (the luminance signal of 4.2 to 5.2 MHz and luminance signal of 5.2 to 6.2 MHz) superposed in the vestigial side band. By controlling the synthesizer of Fig. 6(a), it may be also possible to add the multiplex signal only for the portion of other than the synchronous signal of the original television signal. In this case, as mentioned later, in a video synchronous detector of the system to reproduce the video carrier on the basis of the synchronous signal, there is no deterioration of characteristic due to superposition of the multiplex signal, and an excellent reception performance as in the conventional method can be obtained. Incidentally, the phase of the signal cos ωcc t for frequency conversion may be controlled so as to be inverted at intervals of horizontal at least scanning period, field or frame. This can be said not only to cos ωcc t, but also to other signals for frequency conversion.

Referring now to Fig. 6(b) and Fig. 8, the television multiplex signal processor at the reception side for reproducing the high frequency components of luminance signal is described below.

The received synthetic modulated signal is as shown in Fig. 8(a), which is same as shown in Fig. 7(n). In an ordinary receiver, it corresponds to the tuner output. The synthetic modulated signal is fed into a Nyquist filter 33 and a filter 37. In Fig. 6(b), the part from this Nyquist filter 33 through a video detector 34 to a YC separator 102 is in the same composition as in the ordinary NTSC receiver. The Nyquist filter 33 attenuates a signal amplitude by 6 dB at the position of the video carrier I_1, and it possesses nearly an odd-symmetrical amplitude characteristic with respect to the video carrier I_1. On the other hand, as shown in Fig. 7(m), at the transmission side, since the multiplex signal is limited in the band by the inverse Nyquist filter having the inverse characteristic to the frequency characteristic of the Nyquist filter 33, so that the multiplex signal component in the shaded area of Fig. 8(c) becomes nearly double side band. Therefore, as mentioned above, by synchronous detection, the multiplex signal does not interfere with the main signal.

The multiplex signal demodulation at the reception side is described below. The signal of video intermediate frequency band, which is the tuner output, is limited in the band by the filter 37 (See Fig. 8(b)). The main video signal is subjected to quadrature synchronous detection by the video detector 34, and the multiplex signal is similarly subjected to quadrature synchronous detection by a multiplex signal detector 39, respectively by reproduced video carriers sin ωvc t, cos ωvc t. The detected main video signal is separated into the luminance signal and carrier chrominance signal by a YC separator 102. The carrier chrominance signal is demodulated into chrominance difference signals I and Q by a quadrature demodulator 103, which is exactly the same as in the ordinary NTSC receiver. The luminance signal is fed to an adder 106. On the other hand, the detected multiplex signal is converted in frequency as shown in Fig. 8(f) by a frequency converter 101. Here, the reference phase of signal cos ωcc t necessary for conversion is separately transmitted being multiplexed in, for example, the vertical blanking period, and in this case it is supplied from the YC separator 102. The frequency-converted multiplex signal is separated into the first high frequency luminance signal YH1 and the second high frequency luminance signal YH2 by a YH1, YH2 separator 104, and the former is fed to the adder 106, while the latter is further converted into higher frequency band by a frequency converter 105 and fed to the adder 106. The adder 106 adds the luminance signals from the YC separator 102, the YH1, YH2 separator 104 and the frequency converter 105 to obtain a luminance signal Y in wide range (Fig. 8(j)). In this way, the luminance signal Y in wide range (Fig. 8(j)), and chrominance difference signals I and Q are reproduced.

In most of the existing receivers, the video demodulation is of synchronous detection method, but the reproduction of video carrier is not perfect. That is, the phases are compared where the video carrier of synchronous signal portion is large, but the phases may be deviated due to distortion of the transmission path or the like. And it is preferable not to superpose multiplex signal on the synchronous signal portion. In certain receivers, meanwhile, the detection method of carrier reproduction type is employed, but in this case the axis of detection may be slightly deviated by the multiplex signal. In this sense, when the high frequency component of luminance signal is superposed as in this invention, the quadrature distortion is relatively less obvious. Thus, in the existing receivers, since the multiplex signal is nearly completely canceled by synchronous detection by video carrier, interference by multiplex signal hardly occurs. In the receiver for multiplex signal demodulation, not only the main video signal is obtained in the same way as above but also the multiplex high definition luminance signal can be obtained without quadrature distortion by filtering and synchronous detection. In this method of the invention, furthermore, since the multiplex signal is subjected to quadrature modulation against the video carrier of the main video signal, transmission is similarly possible for motion picture as well as still picture.

Fig. 9(a) is a block diagram showing a television multiplex signal processor at the transmission side for multiplexing the high frequency components of luminance signal and of chrominance signal as one of the embodiments of this invention. Fig. 10 is an explanatory diagram showing the signal waveforms of corresponding parts in Fig. 9(a). Fig. 9(b) is a block diagram showing a television multiplex signal processor

at the reception side for reproducing the high frequency components of luminance signal and of chrominance signal as one of the embodiments of this invention. Fig. 11 is an explanatory diagram showing the signal waveforms of corresponding parts in Fig. 9(b).

First the signal synthesizing method at the transmission side shown in Fig. 9(a) is described. A luminance signal of high frequency range (0 to 5.2 MHz) is added with a carrier chrominance signal at a synthesizer 76. Here, chrominance difference signals I, Q are of high frequency range of 1.5 MHz, and are respectively fed into modulators 71 and 72. The modulators 71 and 72 perform quadrature modulation by carriers sin ωsct and cos ωsct differing in phase from each other by 90 degrees. The outputs of the modulators 71 and 72 pass through band-pass filters 73 and 74 having different characteristics from each other, and are added at an adder 75. The added signal, the carrier chrominance signal, becomes as shown in Fig. 10(d), that is, signal I has components in a range of 2.1 to 4.1 MHz and signal Q, 3.1 to 5.1 MHz. The thus prepared carrier chrominance signal is combined with the luminance signal at the synthesizer 76. Its signal spectrum is shown in Fig. 10(e).

Next, the synthesized signal is separated by a frequency separator 77 into the component of 4.2 MHz and lower and the component over 4.2 MHz. The component up to 4.2 MHz is similar to the ordinary NTSC signal. The component over 4.2 MHz (Fig. 10(f)) is multiplied by a signal cos ωcct of 4.2 MHz to be converted in frequency into a signal of 0 to 1.0 MHz (Fig. 10(g)) by a frequency converter 78. This signal cosωcct for frequency conversion is separately transmitted being multiplexed, for example, in the vertical blanking period. The signal converted into the low frequency range is subjected to quadrature modulation by an amplitude modulator 7 using a video carrier sinωvct, while the component under 4.2 MHz which is compatible with the ordinary NTSC signal is quadrature-modulated by an amplitude modulator 2 using a video carrier cosωvct. In this case, when the direct-current component is preliminary suppressed, the multiplex signal of 1 MHz bandwidth modulated by the amplitude modulator 7 becomes carrier suppressed modulated signal as shown in Fig. 10(i), which is very convenient as stated later. This signal passes through an inverse Nyquist filter 8 having the characteristic as shown in Fig. 10(i). The main video signal modulated by the modulator 2 passes through a VSB filter 3 as shown in Fig. 10(h). The outputs of the filters 8 and 3 are synthesized by a synthesizer 79 to become a composite modulated signal as shown in Fig. 10(j). This composite modulated signal, in comparison with the amplitude modulation in the vestigial side band of an ordinary NTSC video signal, is in such a form that the multiplex signal of about 1 MHz (luminance signal of 4.2 to 5.2 MHz and Q signal of 0.5 to 1.5 MHz) is superposed in the vestigial side band.

By controlling the synthesizer 79, it may be possible to add the multiplex signal only for the portion other than the synchronous signal of the original television signal. In this case, as mentioned above, in the video synchronous detector of the method to reproduce the video carrier on the basis of the synchronous signal, there is no deterioration of characteristic by the superposition of the multiplex signal, so that an excellent reception performance as in the conventional method can be obtained. Besides, depending on the frequency range of the luminance signal fed into the synthesizer 76, it is also possible to transmit only the high frequency component of chrominance signal as the multiplex signal.

The television multiplex signal processor at the reception side for reproducing the high frequency components of luminance signal and of chrominance signal is explained by referring to Fig. 9(b) and Fig. 11.

The received composite modulated signal is as shown in Fig. 11(a), which is same as that shown in Fig. 10(j). In an ordinary receiver, it corresponds to the tuner output. In Fig. 9(b), the composite modulated signal is fed into a Nyquist filter 33 and a filter 37. The part from this Nyquist filter 33 through a video detector 34 to a YC separator 82 is the same composition as in the ordinary NTSC receiver. The Nyquist filter 33 has the same characteristic as mentioned above. On the other hand, as shown in Fig. 10(i), at the transmission side, since the multiplex signal is limited in the band by the inverse Nyquist filter having the inverse characteristic as to frequency characteristic of the Nyquist filter 33, the multiplex signal component in the shaded area of Fig. 11(c) becomes nearly double side band, so that the interference by the multiplex signal with the existing television receiver for video synchronous detection does not occur, in principle.

The multiplex signal demodulation method at the reception side is explained below. The composite modulated signal of video intermediate frequency band which is the tuner output is limited in the band by the filter 37 (Fig. 11(b)). In Fig. 9(b), the video signal, which is the main signal, is subjected to quadrature synchronous detection by the video detector 34 using a video carrier sinωvct, and the multiplex signal is subjected to quadrature synchronous detection by a multiplex signal detector 39 using a video carrier cosωvct. The detected main video signal is separated into luminance signal and carrier chrominance signal by a YC separator 82. The carrier chrominance signal is further demodulated into chrominance difference signals I and Q by a quadrature demodulator 84, which is exactly the same as in the ordinary NTSC receiver. On the other hand, the detected multiplex signal is converted in frequency by a frequency

converter 81 as shown in Fig. 11(f). Here, the signal cosωcct necessary for conversion is transmitted separately as being multiplexed in, for example, the vertical blanking interval, and it is supplied from the YC separator 82 in this case. The frequency-converted multiplex signal is separated into high-frequency luminance signal and high-frequency chrominance signal C' by a YC separator 83, and the former is added with the luminance signal from the YC separator 82 by an adder 85, while the latter is demodulated into high-frequency chrominance difference signal by a chrominance demodulator 86 (Fig. 11(g)). This demodulated chrominance difference signal is added with the chrominance difference signal Q of narrow band by an adder 87 (Fig. 11(k)). Thus, wide-band luminance signal Y (Fig. 11(j)) and 1.5 MHz band chrominance difference signals I and Q are regenerated.

Hereinafter, as one of the embodiments of this invention, a television multiplex signal processor of wide aspect ratio is explained. Fig. 16(a) shows an example of display screen of the existing television, and Fig. 16(b) shows a composite video signal in one scanning line period near the middle of the same screen. Since the aspect ratio is 4:3, of the three circles shown in the display example of Fig. 16(a), a part of each of the right and left circles is cut. Fig. 17(a) shows a display screen of a larger aspect ratio, for example, 5:3 as compared with the existing one, Fig. 17(b) shows a video signal in one scanning line period near the middle of the same screen, and Fig. 17(c) shows a composite video signal added with a synchronous signal and a color burst signal by rewriting the video signal of Fig. 17(b) so that the time-axis scale is equal to that in Fig. 16(b).

When the aspect ratio is increased as shown in Fig. 17(a), more video information can be obtained than the screen shown in Fig. 16(a). Here, in the existing television receiver, if a video signal with aspect ratio of 5:3 is received, in order that the picture can be received as favorably as in the conventional method, that is, in order to keep compatibility, the time-axis is expanded with respect to the television signal in the period displayed on the screen of the existing television receiver. As clear from the comparison between Fig. 16(b) and Fig. 17(c), when the signal of Fig. 17(c) is received by the existing television receiver, it becomes an ellipsis stretched vertically althrough the original picture is circle, and it is necessary to expand the time-axis of the signal of Fig. 17(c). That is, when the original picture is picked up at an aspect ratio m:3 (m is a real number not smaller than 4) stretched laterally than in the conventional case, it is enough to expand the time-axis by m/4 times longer than the picked-up signal corresponding to the portion displayed on the screen of the existing television receiver. Furthermore, in order to obtain a screen information with aspect ratio of m:3, the remaining signal portion is sent by frequency multiplexing. Meanwhile, if the horizontal blanking period is not so required as in the pickup tube, for example, in the case of CCD camera, it is not always necessary to expand the time-axis.

Fig. 12(a) is a block diagram showing a television multiplex signal processor with a wide aspect ratio at the transmission side as one of the embodiments of this invention. In Fig. 12(a), denoted by numeral 111 is an input terminal of luminance signal Y obtained from a signal picked up by a camera having a wider aspect ratio than the existing one, 114 is an input terminal of wide band chrominance difference signal I obtained from the same picked-up signal, 117 is an input terminal of narrow band chrominance difference signal Q obtained from the same picked-up signal, 112, 115 and 118 are signal distributors, 113, 116, 119 and 124 are time-axis expanding circuits, 121 and 123 are adders, 120 and 122 are balanced modulators, 125 is a signal generator, 1 is a main signal input terminal, 6 is a multiplex signal input terminal, 11 is a multiplex signal superposing circuit, and 10 is a composite signal output terminal. The luminance signal Y enters the signal distributor 112, and is distributed into the time-axis expanding circuit 113 and the adder 123. Similarly, the wide band chrominance difference signal I and the narrow band chrominance difference signal Q enter the respective signal distributors 115, 118, and are distributed into the time-axis expanding circuits 116, 119, and the balanced modulator 122. The time-axis can be expanded, for example, by varying the writing and reading clocks of a memory. Conventionally, when the original picture is picked up at an aspect ratio of m:3 (m is a real number not smaller than 4) stretched laterally, the picked-up signal corresponding to the portion displayed on the screen of the existing television receiver is expanded in the time-axis by m/4 times by the time-axis expanding circuits 113, 116, 119. Next, of the chrominance difference signals distributed by the signal distributors 115, 118, the remaining chrominance difference signal components other than the chrominance difference signals expanded by the time-axis expanding circuits 116, 119 are modulated by the balanced modulator 122, and are combined with the remaining luminance component other than the luminance signal expanded by the time-axis expanding circuit 113 by the adder 123. The output of the adder 123 is compressed in the band by the time-axis expanding circuit 124, and is fed into the multiplex signal superposing circuit 11 through the multiplex signal input terminal 6 as a multiplex signal. The output signals of the time-axis expanding circuits 116, 119 are modulated by the balanced modulator 120, and the output of the balanced modulator 120 is added by the adder 121 with the output signal from the time-axis expanding circuit 113 and a synchronous signal, a burst signal and a dis-

criminating signal to distinguish the composite television signal of this processor from the conventional television signal, which are produced at the signal generator 125. The discriminating signal may be, for example, superposed in the vertical blanking period. The output of the adder 121 is fed into the multiplex signal superposing circuit 11 through the main signal input terminal 1 as a main signal. The output of the multiplex signal superposing circuit 11 is the composite signal in which the multiplex signal is superposed on the video base band main signal. The composite signal is transmitted through the transmitter 58 and the antenna 59.

Fig. 12(b) is a block diagram showing a television multiplex signal processor with a wide aspect ratio at the reception side as one of the embodiments of this invention. In Fig. 12(b), denoted by numeral 41 is a multiplex signal separator, 36 is a main signal output terminal, 40 is a multiplex signal output terminal, 132 and 139 are YC separators, 134, 135, 136 and 138 are time-axis compression circuits, 133 and 140 are I, Q demodulators, 137 is a signal selector, 131 is a signal separator, 141 is a matrix circuit, and 142 are R, G, B signal output terminals. The composite signal transmitted from the transmission side and received via the antenna 31 and the tuner 32 is separated into the main signal and the multiplex signal in the multiplex signal separator 41, which are respectively delivered from the main signal output terminal 36 and the multiplex signal output terminal 40. The video base band signal which is the main signal is separated into the luminance signal Y and the chrominance signal C by means of the YC separator 132. The signal Y is compressed in the time-axis by the time-axis compression circuit 134 to become a signal Y_1. The signal C is separated into chrominance difference signals I, Q by means of the I, Q demodulator 133. The signal I is compressed in the time-axis by the time-axis compression circuit 135 to become a signal I_1. The signal Q is compressed in the time-axis by the time-axis compression circuit 136 to become a signal Q_1. The multiplex signal is compressed in the time-axis by the time-axis compression circuit 138, and then is separated into signals Y_2, I_2, and Q_2 by means of the YC separator 139, and the I, Q demodulator 140. The signals Y_1, I_1, Q_1, Yq, I_2 and Q_2 are fed into the signal selector 137, in which the signals Y_1, I_1 and Q_1 are selected for the portion corresponding to the screen of the conventional television receiver with aspect ratio of 4:3, and since they are compressed in the time-axis, as for the remaining period of one horizontal scanning period, the blanking signal or the like is generated and selected inside the signal selector 137 first for the conventional broadcasting, while the signals Y_2, I_2 and Q_2 are selected when receiving said wide television signal. The output signals of the signal selector 137 are converted into R, G, B signals by the matrix circuit 141. The R, G, B signals are fed into the CRT 1000.

Incidentally, the time-axis compression circuits 134, 135, 136, 138 are intended to receive the conventional television signal without any trouble, and to reproduce the television signal by compressing the time-axis expanded portion of the wide television signal having an aspect ratio stretched laterally. That is, as clear from the comparison between Fig. 16(b) and Fig. 17(c), it is necessary to compress the time-axis of the conventional television signal in order to receive the picture of the existing broadcasting without changing the aspect ratio. The compression ratio is determined by the aspect ratio.

The signal separator 131 separates, from the video base band signal, the discriminating signal for distinguishing the television signal of the existing broadcasting from the synchronous signal, color burst signal, and the wide television signal. The signal selector 137 is controlled according to this discriminating signal.

Fig. 13(a) is a block diagram of the signal generator 125 in Fig. 12(a), in which denoted by numeral 126 is a synchronous signal generator, 127 is a burst signal generator, 128 is a discriminating signal generator, and 129 is an adder. The synchronous signal generator 126 and the burst signal generator 127 generate same synchronous and burst signals as those in the conventional broadcasting system. The discriminating signal generator 128 generates a signal to distinguish whether a picture of wide aspect ratio is sent out or not, and for example, a pilot signal or the like superposed in the blanking period as shown in Fig. 13(B). The sum of the outputs of these three generators is delivered as an output from the signal generator 125.

Fig. 14 is a block diagram of the signal separator 131 in Fig. 12(b), which comprises a gate circuit 144. The video base band signal which is the main signal is fed to the gate circuit 144, and discriminating signal is separated from the video base band signal by the gate circuit 144. Since the discriminating signal is superposed, for example, in the blanking period of the video base band signal, its separation is easy.

Fig. 15 is a block diagram of the signal selector 137 in Fig. 12(b), in which denoted by numerals 146, 147 are selectors, and 148 is a blanking signal generator. If the received signal is judged not for a picture with wide aspect ratio by the discriminating signal, Y_1, I_1, Q_1 signals are selected by the selectors 146, 147 in the period corresponding to the screen of aspect ratio of 4:3, and a blanking signal from the blanking signal generator 148 is selected in the other period. If the received signal is judged for a picture with wide aspect ratio by the discriminating signal, Y_2, I_2, Q_2 signals are selected by the selectors 146, 147.

The signal expanded in the time-axis is widened in the band when the time-axis is compressed at the reception side, and therefore the resolution is not lowered even if the aspect ratio becomes larger. The multiplex signal not appearing on the screen of aspect ratio of 4:3, for example, corresponding to the information out of both sides of the screen, is nearly canceled in the conventional receiver by synchronous detection using the video carrier, so that interference by the multiplex signal hardly occurs. In the receiver for multiplex signal demodulation, not only the video base band signal is reproduced by synchronous detection, but also the multiplex signal containing video signal to be displayed on the side portions of a wide aspect ratio screen is reproduced by filtering and synchronous detection using the phase-controlled carrier without quadrature distortion. As for the television signal having the conventional aspect ratio of 4:3, it is displayed near the middle of the monitor of the screen of aspect ratio of 5:3, and the both sides of the screen are, for example, blanked.

Fig. 18 is a block diagram showing a television multiplex signal processor with a wide aspect ratio as one of the embodiments of this invention, in which denoted by numeral 151 is an input terminal of a picture signal of which aspect ratio is greater than 4:3, 152 is a signal distributor, 153 is an NTSC system encoder, 154 is a low-pass filter (LPF), 155 is a time-axis compression circuit, 156 is a time-axis multiplexing circuit, 157 is a subtractor, 158 is a time-axis expansion circuit, 1 is a main signal input terminal, 6 is a multiplex signal input terminal, 11 is a multiplex signal superposing circuit, and 10 is a composite signal output terminal.

Referring to Fig. 18, Fig. 19, Fig. 20, Fig. 21 and Fig. 22, the television multiplex signal processor in the constitution shown in Fig. 18 is described below. Fig. 19 shows a picture of which aspect ratio is 5:3. The picture signal fed into the input terminal 151 is separated, by the signal distributor 152, into a main picture signal for providing an image in the region of aspect ratio of 4:3 sown by (M) in Fig. 19, and a sub picture signal for providing an image in the region indicated by shaded area (S). The main picture signal separated by the signal distributor 152 is encoded by the NTSC system encoder 153 into an NTSC system signal, which is supplied into the time-axis multiplex circuit 156. The sub picture signal separated by the signal distributor 152 is supplied into the LPF 154 and the subtractor 157. This sub picture signal has a waveform as shown in Fig. 20(a), for example, on the time-axis, and on the frequency axis, as a characteristic of general picture signal, it shows a spectrum distribution low in the high frequency energy as shown in Fig. 21(a). By the LPF 154 and the subtractor 157, the sub picture signal is separated into a low frequency component of high energy (waveform in Fig. 20(b), frequency spectrum in Fig. 21(b)), and a high frequency component of relatively low energy (waveform in Fig. 20(d)), frequency spectrum in Fig. 21(d)), which are respectively supplied into the time-axis compression circuit 155 and the time-axis expansion circuit 158. In the time-axis compression circuit 155, the low frequency component shown in Fig. 20(b), Fig. 21(b) is compressed in the time-axis as shown in Fig. 20(c), Fig. 21(c) into a frequency, spectrum below the band that can be transmitted by the NTSC system, and it is supplied into the time-axis multiplex circuit 156. In the time-axis multiplex circuit 156, the low frequency component of the sub picture signal compressed in the time-axis is multiplexed on the time-axis in the horizontal blanking period and vertical blanking period, shown in Fig. 22, of the NTSC system signal composed of the main picture signal. This time-axis multiplexed signal is supplied through the main signal input terminal 1 into the multiplex signal superposing circuit 11. In the time-axis expansion circuit 158, the high frequency component shown in Fig. 20(d), Fig. 21(d) is expanded in the time-axis so that the band is below 1.25 MHz as shown in Fig. 20(e), Fig. 21(e) and is supplied through the multiplex signal input terminal 6 into the multiplex signal superposing circuit 11. From the multiplex signal superposing circuit 11, a composite signal is obtained as described before, and it is delivered from the composite signal output terminal 10 to be transmitted via the transmitter 58 and the antenna 59.

Thus, according to this embodiment, the sub picture signal is separated into low frequency component and high frequency component, and the low frequency component is multiplexed on the time-axis while the high frequency component is multiplexed by quadrature modulation in the vestigial side band of the NTSC system signal, whereby a television signal containing picture information with aspect ratio of larger than 4:3 can be transmitted. When this composite television signal is received by a television receiver of the conventional synchronous detection system, since the high frequency component of the sub picture signal does not have DC component, detection of the NTSC system signal with aspect ratio of 4:3 can be effected without interference. When the same signal is received by a television receiver of envelope detection system, since the high frequency component of the sub picture signal is relatively small in energy, the level of interference is small. In this embodiment, meanwhile, the LPF 154 in Fig. 18 is a one-dimensional one, but it is also possible to use a two-dimensional filter.

As described above, according to this invention, sufficient services of movies or programs of realistic feeling are possible because the image of aspect ratio of, for example, 5:3 is directly reproduced in the receiver. Also, if received by the existing television receiver, the image of aspect ratio of 4:3 can be reproduced with no or small interference. Thus, the present invention is very effective industrially.

Next, multiplex transmission of digital signal is considered. Fig. 23 is a spectral diagram showing a digital multiplex signal processing method at the transmission side as one of the embodiments of this invention. Fig. 23(a) is a spectral diagram of a television signal amplitude-modulated in the vestigial side band in the current television system, in which the lower side band of the video carrier P_1 is the vestigial side band. Fig. 23(b) is a spectral diagram of multiplex signal obtained by phase shift keying (PSK) modulation of subcarrier P_3 by a digital signal preliminarily limited in band by a roll-off filter. Fig. 23(c) shows the multiplex signal limited in the band, in which a carrier P_2 same in frequency as and different in phase by 90 degrees from the video carrier P_1 is amplitude-modulated in double side band so as to remove the carrier P_2. Fig. 23(d) is same as above except that amplitude modulation in single side band is effected instead of amplitude modulation in double side band. Fig. 23(e) is same as above except that amplitude modulation in vestigial side band is effected instead of amplitude modulation in double side band. For example, the signal of Fig. 23(e) multiplexed on the television signal of Fig. 23(a) is the signal shown in Fig. 23(f), and it is an example of television signal synthesized by this invention. In Fig. 23(b), meanwhile, the phase shift keying (PSK) modulation is shown, but other methods of modulation may be employed, such as amplitude shift keying (ASK) modulation and frequency shift keying (FSK) modulation. The phase shift keying modulation may be bi phase shift keying (BPSK) modulation or multi-phase shift keying modulation such as quadri-phase shift keying (QPSK) modulation. Similarly, as for the amplitude shift keying modulation, two-level or multi-level modulation may be possible. Also, as for the frequency shift keying modulation, two-frequency or multi-frequency modulation may be possible. In Fig. 23(f), the signal to be multiplexed is the signal shown in Fig. 23(e), but signals of Fig. 23(c) or Fig. 23(d) may be used.

Fig. 24 is a block diagram showing a digital multiplex signal processor at the transmission side as one of the embodiments of this invention, in which denoted by numeral 11 is a multiplex signal superposing circuit, 1 is a main signal input terminal, 6 is a multiplex signal input terminal, 162 is a digital signal input terminal, 10 is a composite signal output terminal, 163 is an oscillator, and 164 is a quadri-phase modulator. A video base band signal as the main signal is fed through the main signal input terminal 1 into the multiplex signal superposing circuit 11. A digital signal supplied through the digital signal input terminal 162 modulates the subcarrier P_3 generated by the oscillator 163 by quadri-phase shift keying modulation by the quadri-phase modulator 164 to produce a multiplex signal. Incidentally, instead of the quadri-phase modulator 164, other multi-phase shift modulator, frequency modulator or amplitude modulator may be used. The output multiplex signal of the quadri-phase modulator 164 is fed through the multiplex signal input terminal 6 into the multiplex signal superposing circuit 11. The output of the multiplex signal superposing circuit 11 is a composite signal.

As another embodiment of this invention, a digital multiplex signal processor at the reception side is described below. Fig. 25 is a block diagram of this digital multiplex signal processor, in which denoted by numeral 41 is a multiplex signal separator, 36 is a main signal output terminal, 40 is a multiplex signal output terminal, 172 is a quadri-phase demodulator, 171 is a subcarrier regenerator, and 173 is a digital signal output terminal. The signal transmitted from the transmission side is separated into the main signal and the multiplex signal by the multiplex signal separator 41. Incidentally, if the multiplex signal is a signal as shown in Fig. 23(c) or (d), it can be similarly separated and demodulated. The multiplex signal is subjected to quadri-phase shift keying demodulation by the quadri-phase demodulator 172 using the subcarrier I_3 obtained by the subcarrier regenerator 171. In this case, too, instead of the quadri-phase demodulator 172, other multi-phase demodulator, frequency demodulator or amplitude demodulator may be used depending on the transmission side. The demodulation result becomes the original digital signal, and it is delivered from the digital signal output terminal 173. As clear from the explanation above, it is possible to multiplex a large quantity of digital signals within the band of the current television system.

Next are described ghost reduction and crosstalk reduction in the transmission channel. Fig. 26 shows a circuit composition of a transmission apparatus as one of the embodiments of this invention, in which denoted by numeral 181 is a main signal input terminal, 182 is a multiplex signal input terminal, 183 and 184 are reference signal inserters, 185 is a reference signal generator, 186 is a modulator, 187 is a transmission system, 188 is a demodulator, 189 is a ghost reducer, 190 is a main signal output terminal, and 191 is a multiplex signal output terminal. A main signal and a multiplex signal fed through the main signal input terminal 181 and the multiplex signal input terminal 182 are combined with reference signals for ghost reduction generated by the reference signal generator 185 and inserted, in the vertical blanking intervals by the reference signal inserters 183 and 184. The reference signals may have pulse waveform,

bar waveform, sin x/x waveform, or their combined waveform as shown in Figs. 27(a)-(d), but it is required to contain the frequency components in the transmission band sufficiently. Meanwhile, the reference signal waveforms inserted into the main signal and the multiplex signal may be either identical to or different from each other. The main signal and the multiplex signal combined with the reference signals for ghost reduction are subjected to quadrature modulation in the modulator 186. The internal structure of the modulator is same as that shown in Fig. 2, and thus its operation is not repeatedly described here. The transmission system 187 is supposed to contain various high frequency circuits necessary for signal transmission such as tuner and amplifier. In the transmission system 187, group delay distortion, frequency amplitude characteristic distortion and so-called linear distortions are caused by the multi-path transmission or intervened amplifiers. The received signal having such ghost or linear distortion is subjected to quadrature synchronous detection by the demodulator 188, and is separated and demodulated into the main signal and the multiplex signal. The internal structure of the demodulator 188 is same as that shown in Fig. 4, and thus its explanation is omitted here.

The main signal and the multiplex signal, which are outputted from the demodulator 188, contain ghost components and crosstalk components of the respective signals. In the ghost reducer 189, based on the reference signals inserted at the transmission side, a filter having an inverse characteristic to the characteristic of the part containing the modulator 186, transmission system 187 and demodulator 188, regarded as one filter is realized and the ghost components and crosstalk component are canceled. Since a series of signal processings, at the modulator 186, transmission system 187 and demodulator 188 are linear, a filter having a linear inverse characteristic is present, and it may be approximately realized by a two-dimensional transversal filter using two systems of delay lines with taps. An example of internal structure of the ghost reducer 189 is shown in Fig. 28.

Fig. 28 shows a circuit composition of the ghost reducer 189, in which denoted by numeral 190 is a main signal output terminal, 191 is a multiplex signal output terminal, 192 is a main signal input terminal, 193 is a multiplex signal input terminal, 194 is a two-dimensional transversal filter, 195 is a tap coefficient correction arithmetic circuit, 196 and 197 are subtractors, and 198 is a reference signal generator. The internal structure of the two-dimensional transversal filter 194 is shown in Fig. 29.

Fig. 29 shows a circuit composition of the two-dimensional transversal filter 194, in which denoted by numeral 190 is a main signal output terminal, 191 is a multiplex signal output terminal, 192 is a main signal input terminal, 193 is a multiplex signal input terminal, 401 to 416 are multipliers, 417 to 420 are polarity inverters, 421 to 426 are delay lines each with delay time T, 427 to 434 are tap coefficient holders, 435 is a tap coefficient writing terminal, and 436 and 437 are adders.

Referring now to Fig. 28 and Fig. 29, the operation of the ghost reducer 189 is described below.

As mentioned above, basically, the modulator 186 is a quadrature modulator, while the demodulator 188 is a synchronous detector of two axes crossing orthogonally with each other, so that the series of signal processings by the modulator 186, transmission system 187 and demodulator 188 are linear. That is, from the modulator 186, a signal having a complex envelope of which the input signals are real part and imaginary part are sent out, while from the demodulator 188, the complex envelope of the received signal is taken out. Supposing, for example, the sample value trains at each interval T of the reference signals inserted into the original signal and the multiplex signal which are input signals of the modulator 186 to be a_n, b_n, respectively, and defining a complex envelope x_n of a modulated wage as

$$x_n = a_n + j\, b_n \qquad (1)$$

its impulse response h_n is expressed by a complex number because the characteristic is linear from the modulator 186 to the demodulator 188. Therefore, when the output signals of the demodulator 188 corresponding to the reference signals a_n, b_n, that is, the signals at the main signal input terminal 192 and the multiplex signal input terminal 193 in Fig. 28 or Fig. 29 are assumed to be α_n, β_n, a complex signal train y_n defined as

$$y_n = \alpha_n + j\, \beta_n \qquad (2)$$

can be expressed as follows:

$$y_n = \sum_{i=-\infty}^{\infty} x_i \cdot h_{n-i} \qquad \cdots\cdots(3)$$

On the other hand, supposing the output signals of the two-dimensional transversal filter 194 supplied with y_n,that is, the signals at the main signal output terminal 190 and the multiplex signal output terminal 191 in Fig. 28 or Fig. 29 to be An, Bn, defining a complex signal train z_n as

$z_n = A_n + j B_n$ (4)

and the tap coefficients c_{Ri}, C_{Ii} (i = -N to N) of the two-dimensional transversal filter 194 in Fig. 29 as a complex tap coefficient c_i

$c_i = C_{Ri} + j C_{Ii}$ (5)

then Z_n can be expressed, using y_n, as follows:

$$z_n = \sum_{i=-N}^{N} c_i \cdot y_{n-i} = C^t \ Y_n \cdots(6)$$

where

$C^t = [c_{-N} \ldots\ldots c_0 \ldots\ldots c_N]$
$Y^t{}_n = [y_{n+N} \ldots\ldots y_n \ldots\ldots y_{n N}]$

superscript t: transpose.
On the other hand, from equation (3) and equation (6), it follows that

$$\begin{aligned} z_n &= \sum_{i=-N}^{N} c_i \sum_{m=-\infty}^{\infty} x_m \cdot h_{n-i-m} \\ &= \sum_{m=-\infty}^{\infty} x_m \sum_{i=-N}^{N} c_i \cdot h_{n-i-m} \\ &= \sum_{m=-\infty}^{\infty} x_m \cdot s_{n-m} \qquad \cdots\cdots(7) \end{aligned}$$

where,

$$s_n = \sum_{i=-N}^{N} c_i \cdot h_{n-i} \qquad \cdots\cdots(8)$$

The impulse response train s_n is an entire impulse response of the part composed of the modulator 186, transmission system 187, demodulator 188 and two-dimensional transversal filter 194. If the tap number 2N + 1 is infinitely large, it is possible to define accurately as

$$s_n = \sum_{i=-N}^{N} c_i \cdot h_{n-i} = 0 \quad (n \neq 0) \qquad \cdots\cdots(9)$$

$$s_o = \sum_{i=-N}^{N} c_i \cdot h_{-i} = 1 \qquad \cdots\cdots(10)$$

so that the ghost in the transmission system 187, and the linear distortion in the modulator 186 and demodulator 188 can be completely equalized by the two-dimensional transversal filter 194. As a result, the ghost and crosstalk can be eliminated. Actually, however, the tap number is finite, and the conditions of equations (9) and (10) cannot be satisfied perfectly, but, instead, by setting an evaluation function to evaluate the approximation to these conditions and attempting to minimize it, the complex tap coefficient c_i can be optimally selected.

Methods to optimize the complex tap coefficient c_i can be roughly classified into the sequential method and nonsequential method. An example of the former method is described below. More specifically, as the sequential methods zero forcing method, mean square error method, and their combination are known. An example of mean square error method is described below.

In the mean square error method, the following evaluation function E is used.

$$E = \sum_n E_n = \sum_n |z_n - r_n|^2$$
$$= \sum_n |\varepsilon_n|^2 \qquad \cdots\cdots(11)$$

where the complex signal train r_n is a signal train having the reference signal trains for the main signal and the multiplex signal generated by the reference signal generator 198 at the reception side respectively in the real part and imaginary part. The complex signal train r_n is caused to coincide with a complex signal train x_n generated by the reference signal generator 185 at the transmission side. Therefore, equation (11) shows the square sum of the error ϵ_n at each sample point, and this square error E is minimized by the steepest descent method. That is, supposing the tap coefficients after the k-th correction to be ${}^kc_{Ri}$, ${}^kc_{Ii}$, and the complex tap coefficient defined by equation (5) to be ${}^kc_i$, by correcting the sequential tap coefficient so as to fulfill the equations

$${}^{k+1}c_{Ri} = {}^{k}c_{Ri} - \delta \frac{\partial E}{\partial c_{Ri}} \qquad \cdots\cdots(12)$$

$${}^{k+1}c_{Ii} = {}^{k}c_{Ii} - \delta \frac{\partial E}{\partial c_{Ii}} \qquad \cdots\cdots(13)$$

the square error E which is the evaluation function can be minimized. Meanwhile, expressing the complex conjugate by *, and paying attention to the relation of

$$\frac{\partial E}{\partial (j c_{Ii})} = -j \frac{\partial E}{\partial c_{Ii}}$$

equations (12), (13) can be expressed by one expression using equation (11) as follows:

$$ {}^{k+1}c_i = {}^{k}c_i - \delta \frac{\partial E}{\partial c_i^*} \quad \cdots\cdots(13) $$

$$ = {}^{k}c_i - \delta \sum_n \frac{\partial E_n}{\partial c_i^*} \quad \cdots\cdots(14) $$

On the other hand, using equations (6) and (10), the following equation is obtained:

$$ \frac{\partial E_n}{\partial c_i^*} = 2\, \varepsilon_n\, y_{n-i}^* \quad \cdots\cdots(15) $$

Thus, the tap coefficient can be corrected as:

$$ {}^{k+1}C = {}^{k}\underline{C} - \tau \sum_n \varepsilon_n Y_n^* \quad \cdots\cdots(16) $$

$$ (\tau = 2\delta) $$

In Fig. 28, into the tap coefficient correction arithmetic circuit 195, the error signal ϵ_n having the reference signal train r_n subtracted from the output signal train z_n of the two-dimensional transversal filter 194, and the input signal train y_n of the two-dimensional transversal filter 194 are fed by using the subtractors 196, 197, and the reference signal generator 198. In the tap coefficient correction arithmetic circuit 195, calculation as expressed by equation (16) is carried out, and the tap coefficient of the two-dimensional transversal filter 194 is corrected. By repeating this operation, the tap coefficients c_{Ri}, c_{Ii} are converged to the optimum values, so that the ghost and crosstalk are reduced.

Thus, in the multiplex signal processor, known reference signals are inserted into the main signal and the multiplex signal at the transmission side. At the reception side, two demodulated signals separated and demodulated by synchronous detection in the detection phases of two axes orthogonal to each other are passed into two systems of delay lines with taps, and the delayed signals are synthesized with a properly determined weight by using the reference signals that have been received. In other words, by using the two-dimensional transversal filter, a filter having a reverse characteristic to the transmission characteristic of the multi-path transmission, that is, the transmission path in which ghost is present is realized, whereby the distorted two demodulated signals are equalized, so that the original main and multiplex signals are obtained in high quality even in the presence of ghost, and that the cross-talk between the two signals can be reduced at the same time.

Below is explained the case of multiplex transmission by changing over various multiplex signals. Fig. 30 is a block diagram to explain a television signal transmission apparatus as one of the embodiments of this invention, in which denoted by numeral 301 is a control signal superposing circuit, 302 is a control signal generator, 303 is a multiplex signal selection circuit, 11 is a multiplex signal superposing circuit, 305 is a mode selection signal, 306 is a wide band video signal processing circuit, 307 is a wide aspect video signal processing circuit, 308 is an additional sound signal processing circuit, 309 is a small screen video signal processing circuit, 310 is a scramble processing circuit, 311 is a digital data processing circuit, 312 is a video signal selection circuit, and 313 is an ordinary video signal. Moreover, denoted by numeral 10 is a composite signal, 343 is a wide band video signal, 354 is a wide aspect video signal, 361 is an additional sound signal, 362 is a small screen video signal, 363 is a digital data for multiplex, and 373 is a pay-charged video signal.

There are a plurality of selectable signal-transmission modes for transmitting the ordinary video signal, wide band video signal, wide aspect video signal, additional sound signal, small screen video signal, digital data and pay-charged video signal. The mode selection signal 395 is produced by such as a mode selection switch (not shown) for indicating a selected mode. The control signal generator 302 generates,

according to the mode selection signal 395, an error detection-, error correction-coded digital control signal showing the mode which is fed to the control signal superposing circuit 301 and a selection control signal which is applied to the video signal selection circuit 312 and the multiplex signal selection circuit 303. The video signal selection circuit 312 selects, according to the selection control signal, one of the ordinary video signal 313 and video signals supplied from the wide band video signal processing circuit 306, wide aspect video signal processing circuit 307 and scramble processing circuit 310. The control signal superposing circuit 301 superposes the digital control signal from the control signal generator 302 on the video signal selected and supplied from the video signal selection circuit 312 in the vertical blanking period thereof. The multiplex signal selection circuit 303 selects, according to the selection control signal, one of multiplex signals supplied from the processing circuits 306, 307, 308, 309, 310 and 311. The video signal from the control signal superposing circuit 301, regarded as the main signal, and the multiplex signal selected from the multiplex signal selection circuit 303 are fed into the multiplex signal superposing circuit 11, where they are subjected to the quadrature modulation as described before to become the composite signal 10 which will be transmitted.

Hereinafter each block is described, but the description of multiplex signal superposing circuit 11 is omitted because it is given in Fig. 2.

First, the wide band video signal processing circuit 306 in Fig. 30 is as follows. Fig. 31 is a block diagram of the wide band video signal processing circuit 306 in Fig. 30. Denoted by numeral 341 is a low-pass filter (LPF) for passing an ordinary video band (about 4.2 MHz), 342 is a band-pass filter (BPF) (about 4.2 to 5.2 MHz), 343 is a wide band video signal, 344 is an ordinary video signal, 345 is a high frequency video signal, and 346 is a frequency converter. The wide band video signal 343 produced by a camera or the like is limited in band to the same band as that of the existing television signal by the LPF 341 to become the ordinary band video signal 344, which is fed into the video signal selection circuit 312 in Fig. 30. The signal limited in the band by the BPF 342 is converted to a signal of low frequency band of about 1 MHz by the frequency converter 346, and then fed, as the high frequency video signal 345, into the multiplex signal selection circuit 303 in Fig. 30. Needless to say, it is also possible to convert the frequency of the higher frequency portion of the high frequency video signal before the BPF, for example, 5.2 to 6.2 MHz band to 4.2 to 5.2 MHz band.

Next is explained the wide aspect video signal processing circuit 307 in Fig. 30. Fig. 32 is a block diagram of the wide aspect video signal processing circuit 307 in Fig. 30. Denoted by numeral 351 is a time-axis separation circuit, 352 and 353 are time-axis expansion circuits, 354 is a wide aspect video signal, 355 is an ordinary video signal, and 356 is a wide aspect auxiliary video signal. The wide aspect video signal 354 is a video signal for a screen longer in the horizontal direction than usual with an aspect ratio of, for example, 5:3, and its horizontal frequency is same as that of an ordinary television signal (Fig. 33(a)). This signal is divided into the middle portion with aspect ratio 4:3 (Fig. 33(b)), and both side portions (Fig. 33(c)), by the time-axis separation circuit 351. The middle portion is expanded about 5/4 times by the time-axis expansion circuit 352 to become the ordinary video signal 355, which is fed into the video signal selection circuit 312 in Fig. 30. The both side portions are expanded about 4 times by the time-axis expansion circuit 353 to become the wide aspect auxiliary video signal 356, which is fed into the multiplex signal selection circuit 303 in Fig. 30. The widths of the both sides of the screen may not be necessary the same as each other, but a value for indicating the widths may be sent in the vertical blanking period as control data if required.

Next, the sound signal processing circuit 308 in Fig. 30 processing digitally coded sound data is described below. For example, it is possible to sample a sound at about 44 KHz and quantize linearly in 16 bits, so that high quality sound can be transmitted in a band of 1.25 MHz including error correction code (e.g. "A Digital Audio System Based on a PCM Standard Format", the 64th AES, 1979). By using data compression method such as ADPCM, high quality sound of multiple channels can be transmitted digitally, and stereophonic sound or multilingual voice transmissions will be enabled. That is, the sound signal processing circuit 308 is the circuit for converting the format of the digitally coded sound data so as to be transmitted in the video signal period of a television signal. Also, as described later, a format conversion according to the small screen signal may be also effected if required. The additional sound signal 361 in Fig. 30 is converted into a signal in the video signal period by the sound signal processing circuit 308, and is fed into the multiplex signal selection circuit 303. It is also possible to compress an analog sound signal in narrow band on the time-axis, and multiplex it in frequency to transmit as multiple channels.

The small screen video signal processing circuit 309 in Fig. 30 is described below. The small screen video signal 362 in Fig. 30 is a video signal with a band of 1.25 MHz. The small screen video signal processing circuit 309 converts this signal into a signal synchronized with the ordinary video signal 313, and the converted signal is fed, as a multiplex signal, to the multiplex signal selection circuit 303. Since the

band of this multiplex signal is 1.25 MHz, when its resolution is similar to that of the ordinary video signal at identical horizontal and vertical frequencies, it is possible to transmit a signal for a small screen with aspect ratio of 1:3 with respect to the aspect ratio of 4:3 of television screen. When it is divided, for example, into three portions, three small screens each with aspect ratio of 1:1 can be obtained. And one of the three portions may be assigned for a sound transmission channel.

Here, the transmission quantity of digital data is explained. The band for multiplex signal transmission is about 1.25 MHz. In the horizontal blanking period of a television signal, since it is preferable not to multiplex a signal so as not to interfere with the existing receiver, the usable period is abut 50 μs. Therefore, the quantity of data that can be transmitted is 125 bits per horizontal period, but considering the quality of transmission path, error detection and correction are necessary, and thus the practically transmittable quantity is about 80 bits. Considering that the data common to the multiplex signal is transmitted in the vertical blanking period, about 1.1 Mbit data can be transmitted per second. Therefore, in one of the above three small screen portions, the quantity of data that can be transmitted in a second is 80 bits x 160 lines x 30 = 384 Kbits, which means one channel sound signal can be sufficiently transmitted because one channel sound signal is 352 bits if processed by 44 KHz sampling, 8-bit ADPCM coding. It may be naturally understood that the sound signal and the small screen video signal can be changed over as required by the multiplex signal selection circuit 303.

The scramble processing circuit 310 in Fig. 30 is described below. Fig. 34 is a block diagram of the scramble processing circuit 310 in Fig. 30. Denoted by numeral 371 is a video scramble circuit, 372 is a descramble information generating circuit, 373 is a pay-charged video signal, 374 is a scramble code, 375 is a descramble key code, 376 is a scrambled video signal, and 377 is a descramble data. The pay-charged video signal 373 is an ordinary video signal for providing a pay-charged program. This signal is fed into the video scramble circuit 371, in which the video signals to be displayed on the screen are scrambled block by block according to the scramble code 374 to obtain the scrambled video signal 376 for producing an unrecognizable screen image. The descramble information generating circuit 372 produces the descramble data 377 for descrambling the scrambled video signal according to the scramble code 374 and the descramble key code 375. The scramble key code 374 and descramble key code 375 are supplied, for example, from a computer (not shown). The descramble key code is the data relating to the code of, for example, subscribed user, and since a larger quantity of information than before can be transmitted, complicated scrambling which is not possible conventionally can be realized, such as transmission of different key codes to respective users, or changing of the scrambling format with the time. At this time, when a program identification code is transmitted, automatic charging can be processed easily.

The digital data processing circuit 311 in Fig. 30 is described below. The data transmission quantity and method are same as those described in connection with the sound signal processing circuit 308. However, it is not necessary that the signal is synchronized with the screen image. The digital data 363 is for data communication such as facsimile data, and it is formated so as to be transmitted in the video signal period by the digital data processing circuit 311, and fed into the multiplex signal selection circuit 303. When used for data communication, facsimile data or the like can be transmitted at higher rate than before.

Referring now to Fig. 35, a television signal receiver as one of the embodiments of this invention is described below. Denoted by numeral 41 is a multiplex signal separator, 482 is a control signal sampling circuit, 483 is a decoding control signal generator, 484 is a video signal selector, 485 is a high frequency video signal adding circuit, 486 is a wide aspect video signal adding circuit, 487 is a scramble decoding circuit, 488 is a small screen video signal adding circuit, 489 is a multiplex sound signal decoding circuit, 490 is a multiplex digital data decoding circuit, 491 is a sound processing circuit, 492 is a display unit, 493 is a sound generator, 494 is a demodulated video signal, 495 is a demodulated multiplex signal, and 496 is a decoded digital data.

The new composite television signal transmitted from the transmitting apparatus in Fig. 30 is received via the antenna 31 and the tuner 32, and fed into the multiplex signal separator 41.

In the multiplex signal separator 41, the composite television signal is separated and subjected to quadrature detection to become the demodulated video signal 494 and the demodulated multiplex signal 495. From the video signal 494, the control signal superposed in the vertical blanking period is extracted by the control signal sampling circuit 483, and sent to the decoding control signal generator 483. The decoding control signal generator 483 generates decoding control signals for controlling the circuits 484 through 490. One of various video signals that are decoded by respective circuits 485 through 488 is selected by the video signal selector 484, and sent to the display unit 492 to produce a television screen image. The display unit 492 is, for example, a CRT with aspect ratio of 5:4. The decoded sound signal from the

multiplex sound signal decoding circuit 489 is processed by the sound processing circuit 491, and sent to the sound generator 493 such as a speaker. Hereinafter each block is described in details, but the multiplex signal separator 41 which is described in connection with Fig. 4 is not mentioned below.

First, the high frequency video signal adding circuit 485 in Fig. 35 is as follows. Fig. 36 is a block diagram of the high frequency video signal adding circuit 485, in which denoted by numeral 550 is a frequency converter, 551 is a wide band video signal synthesizer, and 552 is a decoded wide band video signal. The demodulated multiplex signal 495 is reconverted to its original band by the frequency converter 550 controlled by the decoding control signal 553, and is combined with the demodulated video signal 494 in the wide band signal synthesizer 551 to become the decoded wide band signal 552. This signal 552 is fed into the video signal selector 484 in Fig. 35.

The wide aspect video signal adding circuit 486 in Fig. 35 is as follows. Fig. 37 is a block diagram of the wide aspect video signal adding circuit 486, in which denoted by numerals 561 and 562 are time-axis compression circuits, 563 is a wide aspect video signal synthesizer, and 564 is a decoded wide aspect video signal. The decoding operation is the reverse operation to that at the transmission side shown in Fig. 32 and Fig. 33. The decoded signal 564 is the signal to be displayed on a screen longer in the horizontal direction than the current one. The widths of the the both sides of the screen can be controlled by the decoding control signal 565 from the decoding control signal generator 563 when necessary.

The scramble decoding circuit 487 in Fig. 35 is described below. Fig. 38 is a block diagram of the scramble decoding circuit 487, in which denoted by numeral 571 is a scramble decoder, 572 is a descramble control circuit, 573 is a decoded pay-charged video signal, and 574 is a user key code. From the demodulated multiplex signal 495, the decoding control signal 575, and a user key code 574 which is supplied from, for example, a microcomputer (not shown), a control signal for descrambling is generated. According to this control signal, the scramble decoding circuit 571 decodes the demodulated video signal 494 to obtain decoded pay-charged video signal 573 providing a recognizable screen image.

The small screen video signal adding circuit 488 in Fig. 35 is described below. Fig. 39 is a block diagram of the small screen video signal adding circuit 488, in which denoted by numeral 581 and 582 are time-axis compression circuits, 583 is a small screen video signal synthesizer, and 584 is a video signal with decoded small screen video signal.

Explaining by referring to Fig. 40, the demodulated video signal 494 in Fig. 40(a) is compressed so as to be positioned at the left side of the screen by the time-axis compression circuit 581, and the small screen signal of demodulated multiplex signal 495 in Fig. 40(b) is compressed by the time-axis compression circuit 582 so as to be positioned at the right side of the screen, and they are synthesized as shown in Fig. 40(c) by the small screen signal synthesizer 583 so as to become the video signal with decoded small screen video signal 584. Instead of the right end of the screen as explained above, a small screen may be similarly disposed at a desired position on the screen according to the decoding control signal 585.

The multiplex sound signal decoding circuit 489 and multiplex digital data decoding circuit 490 in Fig. 35 may function in the reverse manners to those at the transmission side, and thus, their detailed descriptions are hence omitted.

In addition to the television system of wide aspect ratio described hereabove, another embodiment of such system is described below. Concerning the television system of wide aspect ratio, to begin with, signal processing at the transmission side is explained herein. Fig. 41 is a block diagram of a television multiplex signal processor with wide aspect ratio at the transmission side as one of the embodiments of this invention, in which denoted by numeral 601 is a luminance signal generating circuit, 602 is an I (chrominance difference) signal generating circuit 603 is a Q (chrominance difference) signal generating circuit. The signal generating circuits 601, 602 and 603 generate a luminance signal, a wide band I signal and a narrow band Q signal, respectively, from a signal picked up by a television camera (not shown) having a larger aspect ratio than the conventional aspect ratio of 4:3. Denoted by 604, 605, 606 are time-axis expansion circuits, 607 is an NTSC system encoder, 608 is a time-axis multiplexing circuit, 609 is an adder, 610 is a multiplex signal processing circuit, 611 is a luminance signal input terminal, 612 is an I signal input terminal, 613 is a Q signal input terminal, 614 is a multiplex signal output terminal, 615 is a time-axis multiplex signal output terminal, 125 is a signal generating circuit, 11 is a multiplex signal superposing circuit, 58 is a transmitter, 59 is an antenna, 1 is a main signal input terminal, 6 is a multiplex signal input terminal, and 10 is a composite signal output terminal. Incidentally, the antenna is illustrated, but the transmission path is not limited to wireless system, but it may be a wired system. Meanwhile, the signal generating circuit 125, multiplex signal superposing circuit 11, transmitter 58, and antenna 59 have been described in connection with Fig. 2 and Fig. 12, and explanations thereof are omitted from the following description.

The luminance signal generated by the luminance signal generating circuit 601 is fed into the time-axis expansion circuit 604 and through the terminal 611 into the multiplex signal processing circuit 610. Similarly, the wide band I signal and narrow band Q signal which are respectively generated by the I signal generating circuit 602 and Q signal generating circuit 603 are respectively fed into the time-axis expansion circuit 605 and time-axis expansion circuit 606 and through terminals 612, 613 into the multiplex signal processing circuit 610. When the original picture is picked at a horizontally stretched aspect ratio m:3 (m is a real number not smaller than 4), the signal corresponding to the portion displayed on the screen of the existing television receiver is expanded in the time-axis by m/4 times in each of the time-axis expansion circuits 604, 605, 606. The luminance signal and chrominance difference signal components in the remaining period other than those expanded by the time-axis expansion circuits 604, 605, 606 are converted by the multiplex signal processing circuit 610 into a time-axis multiplex signal and a frequency-axis multiplex signal, which are fed into the time-axis multiplex circuit 608 through the terminal 615 and the multiplex signal superposing circuit 11 through the terminal 614, respectively. The time-axis expanded output signals from the time-axis expansion circuits 604, 605, 606 are converted into an NTSC signal in the know manner by the NTSC system encoder 607. Its output is combined with the time-axis multiplex signal by the time-axis multiplex circuit 608. The time-axis multiplex circuit 608 is required to have only an adding function. And its output is combined, by the adder 609, with a synchronous signal, a burst signal, and a discriminating signal for distinguishing the wide television signal from the conventional television signal, which are supplied from the signal generating circuit 125. The discriminating signal is superposed, for example, in the vertical blanking period. The output of the adder 609 and the frequency-axis multiplex signal are synthesized in the multiplex signal superposing circuit 11 to be a composite signal, which is transmitted through the transmitter 58 and antenna 59.

Fig. 42 is a block diagram showing an example of internal structure of the multiplex signal processing circuit 610 in Fig. 41. In Fig. 42, denoted by numeral 611 is a luminance signal input terminal, 612 is an I signal input terminal, 613 is a Q signal input terminal, 614 is a multiplex signal output terminal, 615 is a time-axis multiplex signal output terminal, 621, 624, 625 are low-pass filters (LPFs), 622 is a subtractor, 626, 627, 628 are time-axis compression circuits, 623 is a time-axis expansion circuit, and 629 is a time-axis adjusting circuit.

Referring now to Fig. 20, Fig. 21, and Fig. 22, the television multiplex signal processor having the constitution as shown in Fig. 41 and Fig. 42 is described below. The signal corresponding to the portion displayed on the screen of the existing television receiver is supposed to be a main signal, and the signal corresponding to other portion, such as both sides of the wide aspect ratio screen, be a multiplex signal. The part of the luminance signal for the multiplex signal is fed through the luminance signal input terminal 611 into the LPF 621 and subtractor 622. This signal, for example, has a waveform as shown in Fig. 20(a), and on the frequency-axis it presents a spectrum profile of low energy of high frequency as shown in Fig. 21(a) as a general characteristic of such signal. By the LPF 621 and subtractor 622, the luminance signal is separated into a low frequency component with high energy (waveform in Fig. 20(b), frequency spectrum in Fig. 21(b)) and a high frequency component with relatively low energy (waveform in Fig. 20(d), frequency spectrum in Fig. 21(d)), which are respectively supplied into the time-axis compression circuit 626 and time-axis expansion circuit 623. In the time-axis compression circuit 626, the low frequency component shown in Fig. 20(b), Fig. 21(b) is compressed in the time-axis into a signal having the frequency spectrum settling within the band that can be transmitted by the NTSC system as shown in Fig. 20(c), Fig. 21(c). The compressed signal Y_0 is supplied into the time-axis adjusting circuit 629. In the time-axis adjusting circuit 629, the time-axis of the low frequency component of the luminance signal compressed in the time-axis is adjusted so that the signal can be multiplexed at least in the horizontal blanking period and vertical blanking period of the NTSC system signal composed of the main signal as shown in Fig. 22. For the adjustment of time-axis, for example, the signals Y_0, I_0, Q_0 may be each delayed by a memory or the like so that the signals are located in the vertical blanking interval sequentially in the order of, for example, Y_0, I_0 and Q_0. The output of the time-axis adjusting circuit 629 is the time-axis multiplex signal. In the time-axis expansion circuit 623, the high frequency component shown in Figs. 20(d), 21(d) is expanded in the time-axis so that the band becomes below the level of frequency-axis multiplexing to obtain the frequency-axis multiplex signal 614 as shown in Fig. 20(e), Fig. 21(e). Next, I signal and Q signal are limited in the band under the level transmittable by the NTSC system, by means of the LPFs 624, 625, and time-axis compression circuits 627, 628, respectively. The outputs I_0, Q_0 of the time-axis compression circuits 627, 628 are adjusted in time so as not to overlap with the luminance signal at least in the horizontal blanking period and vertical blanking period of the NTSC system signal composed of the main signal in the time-axis adjusting circuit 629.

Fig. 43 is a block diagram showing a television multiplex signal processor with a wide aspect ratio at the reception side as one of the embodiments of this invention, in which denoted by numeral 41 is a multiplex signal separator, 131 is a signal separator, 132 is a YC separator, 133 is an I, Q demodulator, 134, 135, 136 are time-axis compression circuits corresponding to the time-axis expansion at the transmission side, 137 is a signal selector, 701 is a multiplex signal regenerator, 141 is a matrix circuit, 142 are R, G, B signal output terminals, 36 is a main signal output terminal, 40 is a multiplex signal output terminal, 702 is a main signal input terminal, and 703 is a multiplex signal input terminal. The signal transmitted from the transmission side shown in Fig. 41 and received via the antenna 31 and the tuner 32 is separated into the main signal and the frequency-axis multiplex signal by the multiplex signal separator 41, which signals are respectively delivered through the main signal output terminal 36 and multiplex signal output terminal 40. The video base band signal which is a main signal is separated into luminance (Y) signal and carrier chrominance (C) signal by the YC separator 132. The Y signal is compressed in the time-axis by the time-axis compression circuit 134 to become Y_1 signal. The C signal is separated into I signal and Q signal by the I, Q demodulator 133. The I signal is compressed in the time-axis by the time-axis compression circuit 135 to become I_1 signal, while the Q signal is compressed in the time-axis by the time-axis compression circuit 136 to become Q_1 signal. The frequency-axis multiplex signal is transformed into Y_2 signal, I_2 signal, Q_2 signal by the multiplex signal regenerator 701. These signals Y_1, I_1, Q_1, Y_2, I_2, Q_2 are fed into the signal selector 137, in which Y_1, I_1, Q_1 signals are selected for the portion corresponding to the screen of the existing television receiver with aspect ratio of 4:3. For the remaining period of one horizontal scanning period, a blanking signal or the like generated inside the signal selector 137 is selected when the conventional television signal is received, whereas Y_2, I_2, Q_2 signals are selected when the wide television signal is received. The output signal of the signal selector 137 is changed into R, G, B signals by the matrix circuit 141. Meanwhile, the time-axis compression circuits 134, 135, 136 are intended to recover the wide television signal by compressing the time-axis expanded portion of the television signal having a horizontally stretched aspect ratio, as well as to allow the conventional television signal to be received without trouble. This compression ratio is determined by the aspect ratio. However, if the display unit 1000 is liquid crystal display or the like and the blanking period is not so required as in the CRT, it is not always required to compress the time-axis. Incidentally, the multiplex signal separator 41, signal separator 131, YC separator 132, I, Q demodulator 133, time-axis compression circuits 134, 135, 136, signal selector 137, and matrix circuit 141 have been described in connection with Fig. 12(b), and are omitted from the present explanations.

Fig. 44 is a block diagram showing an example of internal structure of the multiplex signal regenerator 701 in Fig. 43. This is a signal processing circuit at the reception side corresponding to the example of multiplex signal processing circuit 601 in Fig. 42 at the transmission side. In Fig. 44, denoted by numeral 703 is a multiplex signal input terminal, 702 is a main signal input terminal, 711 is a time-area compression circuit, 712 is an adder, 713 is a time-axis adjusting circuit, and 714, 715, 716 are time-axis expansion circuits. The multiplex signal expanded by the time-axis by the time-axis expansion circuit 623 in Fig. 42 is compressed in the time-axis by the time-axis compression circuit 711. The signal superposed in the blanking period of the main signal fed through the main signal input terminal 702 is returned to the initial time relation by the time-axis adjusting circuit 713 having delay elements such as memories. Signals Y_0, I_0, Q_0 which are outputs of the time-axis adjusting circuit 713 and correspond to the signals Y_0, I_0, Q_0 compressed in the time-axis by the time-axis compression circuits 626, 627, 628 in Fig. 42 are expanded in the time-axis by the time-axis expansion circuits 714, 715, 716, respectively. Outputs of the time-axis expansion circuits 715, 716 are I_2 and Q_2 signals. The output of the time-axis expansion circuit 714 is combined with the output of the time-axis compression circuit 711 by the adder 712 to become Y_2 signal. This adder 712 corresponds to the one-dimensional LPF 621 at the transmission side considered in Fig. 42, and if the filter is two-dimensional, two-dimensional processing corresponding to its inverse calculation is necessary.

In this way, by separating the multiplex signal into low frequency component and high frequency component, and multiplexing the low frequency component on the time-axis in the blanking period and multiplexing the high frequency component of small power on the frequency-axis, the multiplex signal hardly interferes with the existing television receiver, and such television signals that contain video information with aspect ratio of greater than 4:3 can be transmitted and regenerated.

Claims

1. An apparatus for transmitting a wide aspect ratio television signal corresponding to an image displayed on a television screen having a wider aspect ratio than 4:3, comprising:
   a first time-axis expanding means (113, 116, 119) for expanding on time-axis a first part of said wide aspect ratio television signal to obtain a first television signal, said first part corresponding to a part having the aspect ratio of 4:3 of said wide aspect ratio television signal;
   a second time-axis expanding means (124) for expanding on time-axis a second part which is the remaining part of said wide aspect ratio television signal to obtain a second television signal;
   a frequency-axis multiplexing means (11) for multiplexing said first and second television signals on frequency axis to obtain a multiplexed television signal; and
   a means (58) for transmitting said multiplexed television signal.

2. An apparatus according to claim 1, wherein said frequency-axis multiplexing means comprises:
   a carrier generating means (4, 5) for generating first and second carriers which are equal in frequency to and different in phase by 90° from each other;
   a first amplitude-modulating means (2) for amplitude modulating said first carrier by said first television signal to obtain a first vestigial sideband, amplitude-modulated television signal;
   a second amplitude-modulating means (7) for amplitude modulating said second carrier by said second television signal to obtain a double sideband, amplitude-modulated television signal;
   an inverse Nyquist filter (8) coupled to said second amplitude-modulating means and having a Nyquist characteristic for filtering said double sideband, amplitude-modulated television signal to obtain a second vestigial sideband, amplitude-modulated television signal, said inverse Nyquist filter having a frequency characteristic which is substantially symmetrical with respect to a frequency of said first carrier to a frequency characteristic of a Nyquist filter (33) which is provided in a video detecting stage of a television receiver;
   an adding means (9) for adding said first and second vestigial sideband, amplitude-modulated television signal to obtain said multiplexed television signal.

3. An apparatus for receiving a multiplexed television signal transmitted from an apparatus according to claim 1, comprising:
   a means (32) for receiving said multiplexed television signal;
   a signal separating means (41) for separating the received multiplexed television signal into said first and second television signals;
   a first time-axis compressing means (134, 135, 136) for compressing on time axis said first television signal to obtain said first part of said wide aspect ratio television signal;
   a second time-axis compressing means (138) for compressing on time axis said second television signal to obtain said second part of said wide aspect ratio television signal; and
   a means (137) for composing said wide aspect ratio television signal from said first and second parts.

4. An apparatus according to claim 3, wherein said signal separating means (41) comprises:
   a Nyquist filter (33) for filtering said multiplexed television signal;
   a carrier regenerating means (35, 38) for regenerating from said multiplexed television signal first and second carriers which are equal in frequency to and different in phase by 90° from each other;
   a first detecting means (34) for detecting said first television signal from said multiplexed television signal passed through said Nyquist filter by using said regenerated first carrier;
   a filter (37) for passing said multiplexed television signal to remove quadrature distortion; and
   a second detecting means (39) for detecting said second television signal from said multiplexed television signal passed through said filter by using said regenerated second carrier.

5. An apparatus for transmitting a wide aspect ratio television signal corresponding to an image displayed on a television screen having a wider aspect ratio than 4:3, comprising:
   a first time-axis expanding means (152, 153) for expanding on time-axis a first part of said wide aspect ratio television signal to obtain a first television signal, said first part corresponding to a part having the aspect ratio of 4:3 of said wide aspect ratio television signal;
   a signal separating means (154, 157) for separating the remaining part other than said first part of the wide aspect ratio television signal into second and third parts;

a time-axis compressing means (155) for compressing on time axis said second part to obtain a second television signal;

a second time-axis expanding means (158) for expanding on time-axis said third part to obtain an additional information signal;

a time-axis multiplexing means (156) for multiplexing on time axis said first and second television signals to obtain a main television signal;

a frequency-axis multiplexing means (11) for multiplexing on frequency-axis said main and additional information signals to obtain a multiplexed television signal; and

a means (58) for transmitting said multiplexed television signal.

6. An apparatus according to claim 3, wherein said frequency-axis multiplexing means comprises:

a carrier generating means (4, 5) for generating first and second carriers which are equal in frequency to and different in phase by 90° from each other;

a first amplitude-modulating means (2) for amplitude modulating said first carrier by said main television signal to obtain a vestigial sideband, amplitude-modulated television signal;

a second amplitude-modulating means (7) for amplitude modulating said second carrier by said additional information signal to obtain a double sideband, amplitude-modulated additional information signal;

an inverse Nyquist filter (8) coupled to said second amplitude-modulating means and having a Nyquist characteristic for filtering said double sideband, amplitude-modulated additional information signal to obtain a vestigial sideband, amplitude-modulated additional information signal, said inverse Nyquist filter having a frequency characteristic which is substantially symmetrical with respect to a frequency of said first carrier to a frequency characteristic of a Nyquist filter (33) which is provided in a video detecting stage of a television receiver;

an adding means (9) for adding said vestigial sideband, amplitude-modulated television and additional information signals to obtain said multiplexed television signal.

7. An apparatus for receiving a multiplexed television signal transmitted from an apparatus according to claim 5, comprising:

a means (32) for receiving said multiplexed television signal;

a first signal separating means (41) for separating the received multiplexed television signal into said main television signal and said additional information signal;

a second signal separating means (713) for separating said main television signal into said first and second television signals;

a first time-axis compressing means (134, 135, 136) for compressing on time axis said separated first television signal to obtain said first part of said wide aspect ratio television signal;

a time-axis expanding means (714, 715, 716) for expanding on time axis said separated second television signal to obtain said second part of said wide aspect ratio television signal;

a second time-axis compressing means (711) for compressing on time axis said separated additional information signal to obtain said third part of said wide aspect ratio television signal; and

a means (137) for composing said wide aspect ratio television signal from said first, second and third parts.

8. An apparatus according to claim 7, wherein said first signal separating means (41) comprises:

a Nyquist filter (33) for filtering said multiplexed television signal;

a carrier regenerating means (35, 38) for regenerating from said multiplexed television signal first and second carriers which are equal in frequency to and different in phase by 90° from each other;

a first detecting means (34) for detecting said main television signal from said multiplexed television signal passed through said Nyquist filter by using said regenerated first carrier;

a filter (37) for passing said multiplexed television signal to remove quadrature distortion; and

a second detecting means (39) for detecting said additional information signal from said multiplexed television signal passed through said filter by using said regenerated second carrier.

FIG. 1

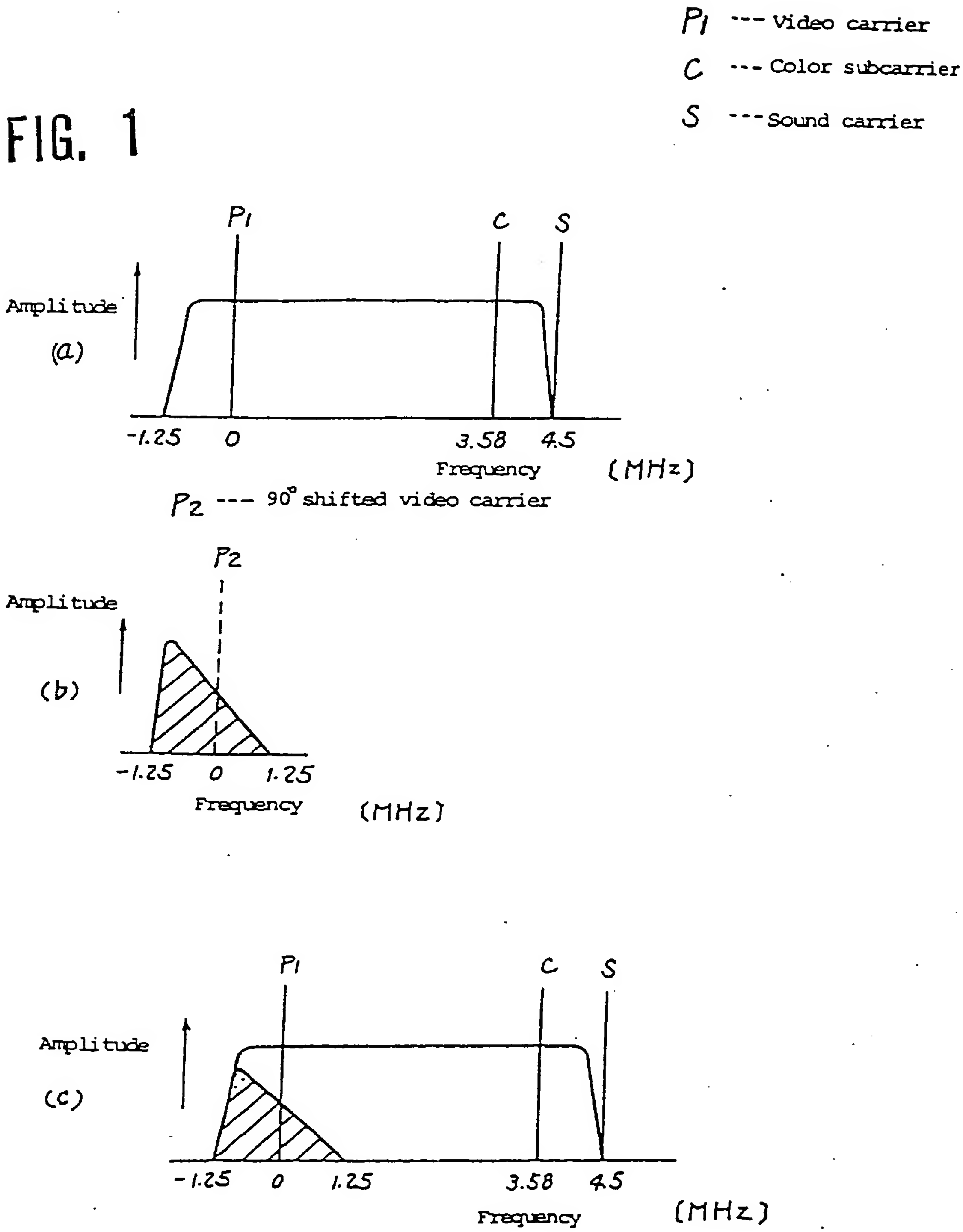

P1 --- Video carrier
C --- Color subcarrier
S --- Sound carrier
P1
C
S
Amplitude
(a)
-1.25
0
3.58
4.5
Frequency
(MHz)
P2 --- 90° shifted video carrier
P2
Amplitude
(b)
-1.25
0
1.25
Frequency
(MHz)
P1
C
S
Amplitude
(c)
-1.25
0
1.25
3.58
4.5
Frequency
(MHz)

FIG. 2

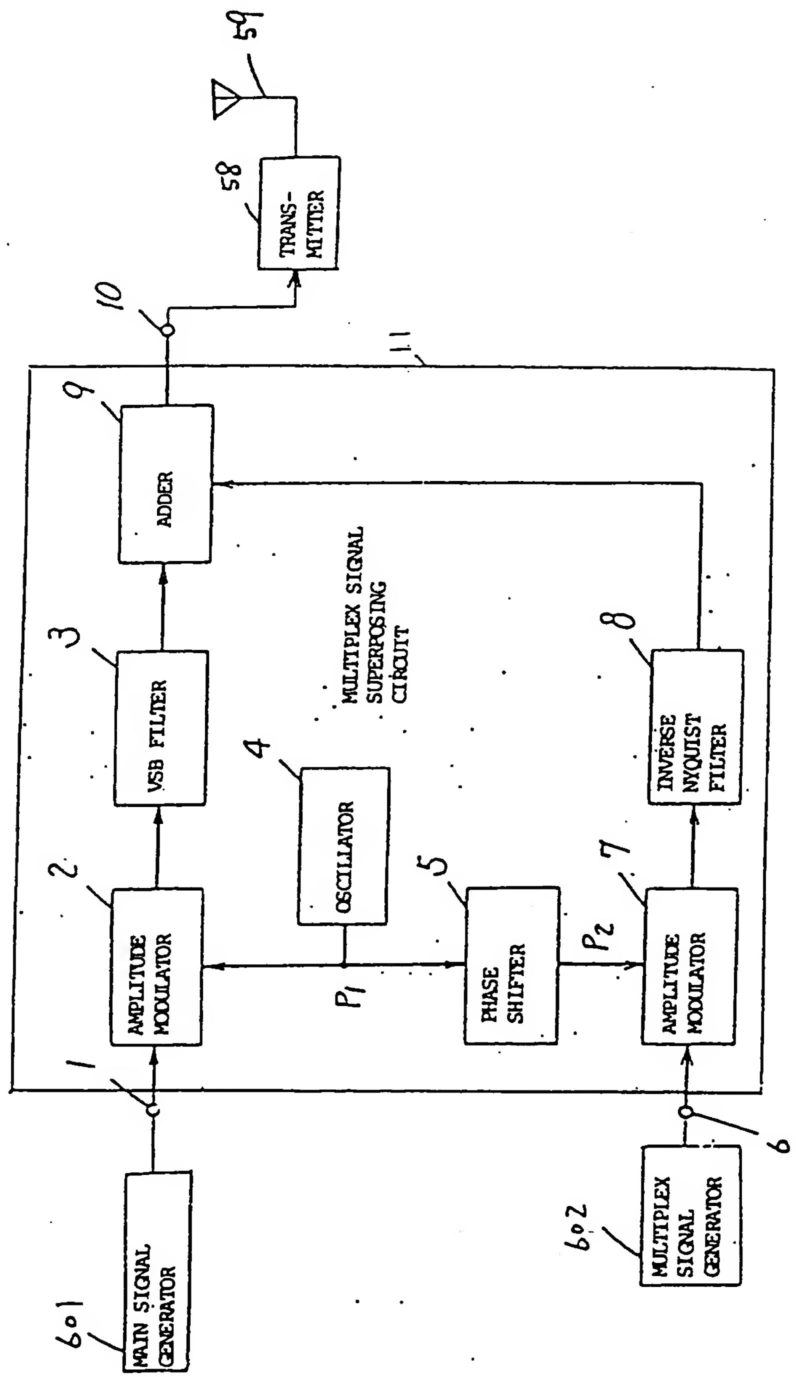

MAIN SIGNAL GENERATOR
601
MULTIPLEX SIGNAL GENERATOR
602
1
6
AMPLITUDE MODULATOR
2
VSB FILTER
3
ADDER
9
OSCILLATOR
4
P1
PHASE SHIFTER
5
P2
AMPLITUDE MODULATOR
7
INVERSE NYQUIST FILTER
8
MULTIPLEX SIGNAL SUPERPOSING CIRCUIT
11
10
TRANS-MITTER
58
59

FIG. 3 (a)

PRIOR ART

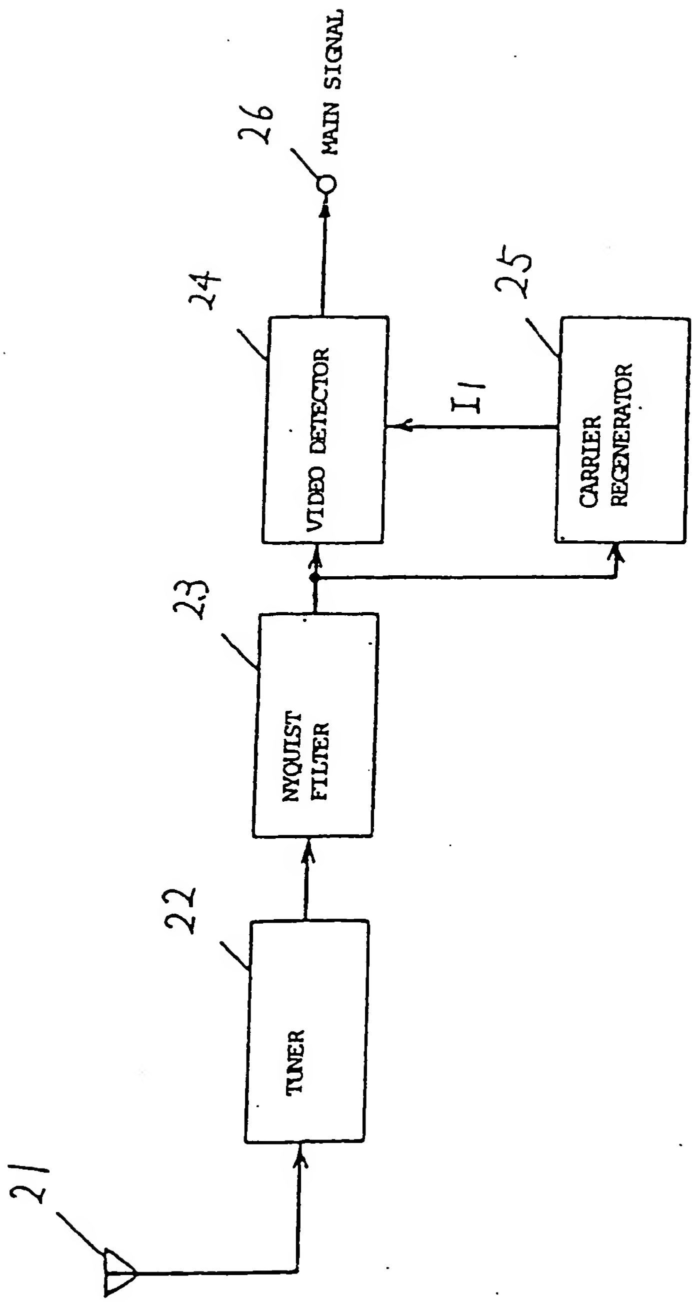


FIG. 3 (b)

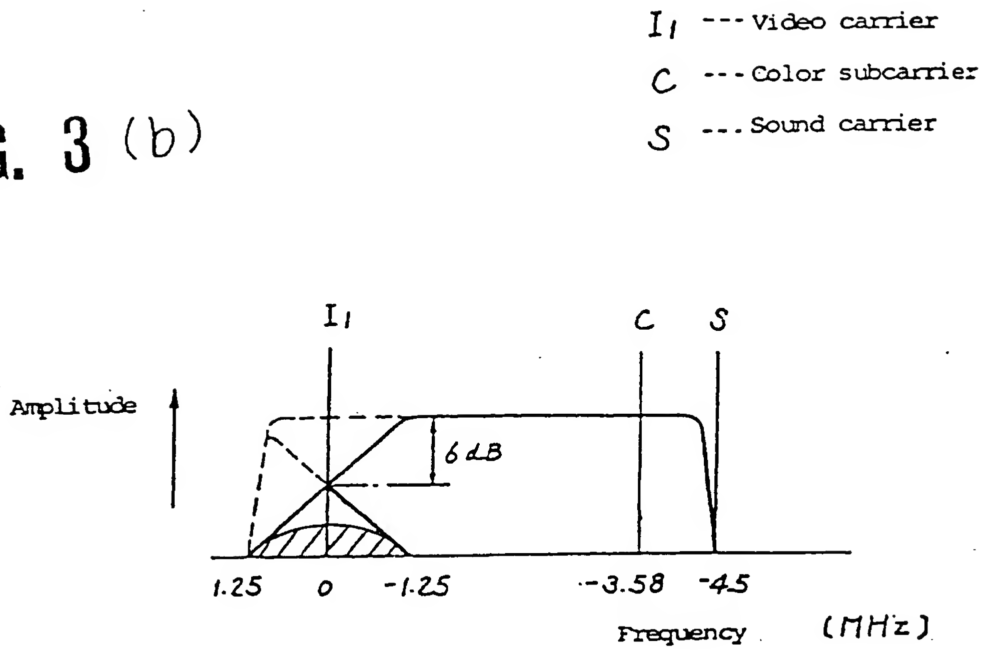

I_1 --- Video carrier
C --- Color subcarrier
S --- Sound carrier
I_1
C
S
Amplitude
6 dB
1.25
0
-1.25
-3.58
-4.5
Frequency
(MHz)

FIG. 3 (c)

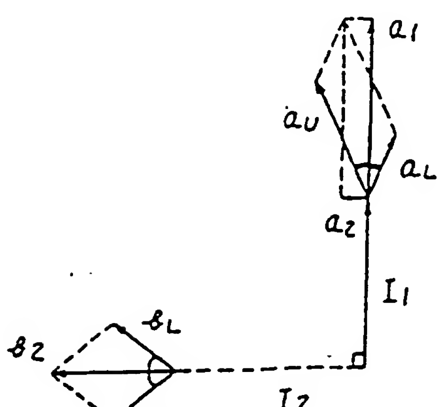
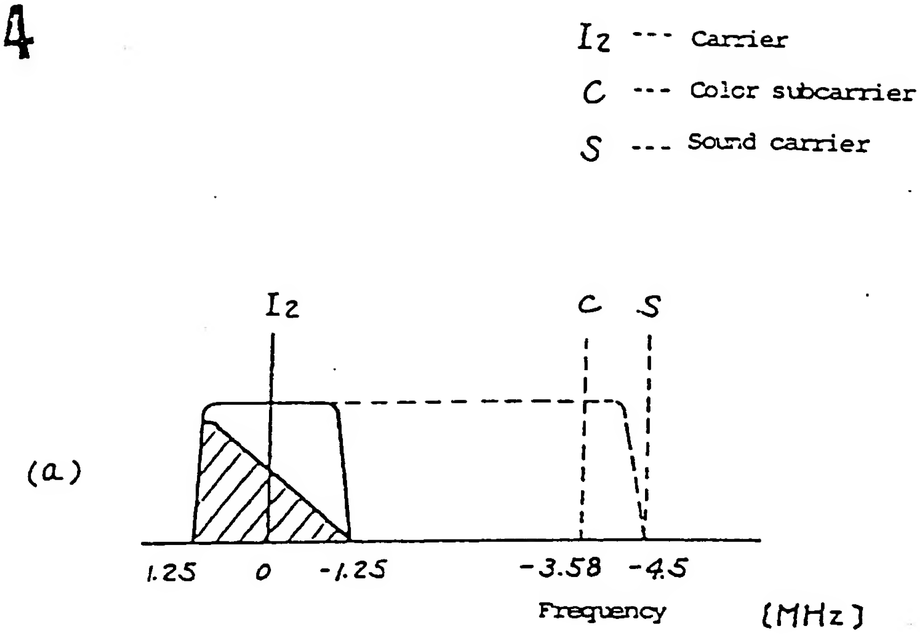

a_1
a_U
a_L
a_2
I_1
b_L
b_2
b_U
I_2

FIG. 4


I2 --- Carrier
C --- Color subcarrier
S --- Sound carrier
(a)
I2
C
S
1.25
0
-1.25
-3.58
-4.5
Frequency
[MHz]

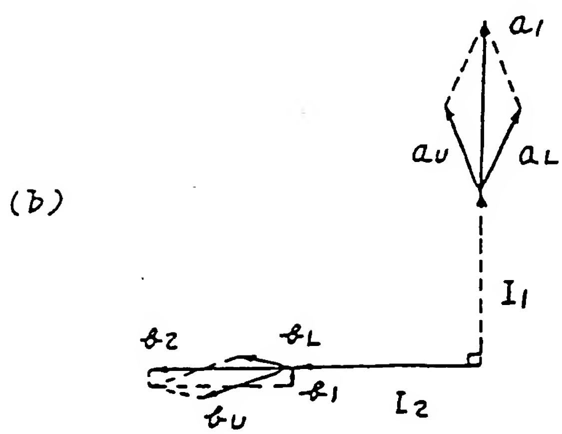

(b)
a1
aU
aL
I1
b2
bL
b1
bU
I2

FIG. 4 (C)

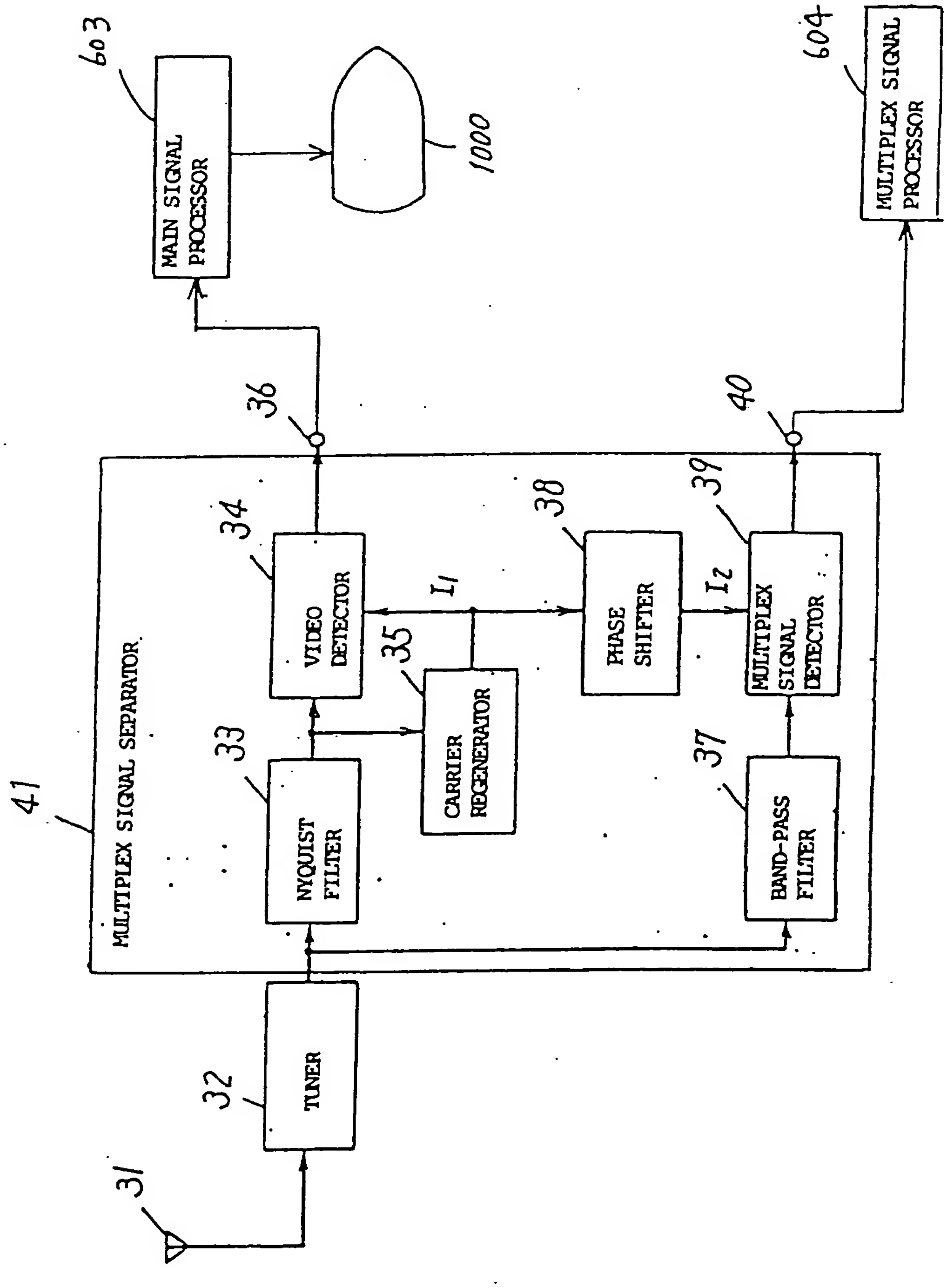

31
32
TUNER
41
MULTIPLEX SIGNAL SEPARATOR
33
NYQUIST FILTER
34
VIDEO DETECTOR
35
CARRIER REGENERATOR
36
I_1
38
PHASE SHIFTER
I_2
39
MULTIPLEX SIGNAL DETECTOR
37
BAND-PASS FILTER
40
603
MAIN SIGNAL PROCESSOR
1000
604
MULTIPLEX SIGNAL PROCESSOR

FIG. 5 (a)

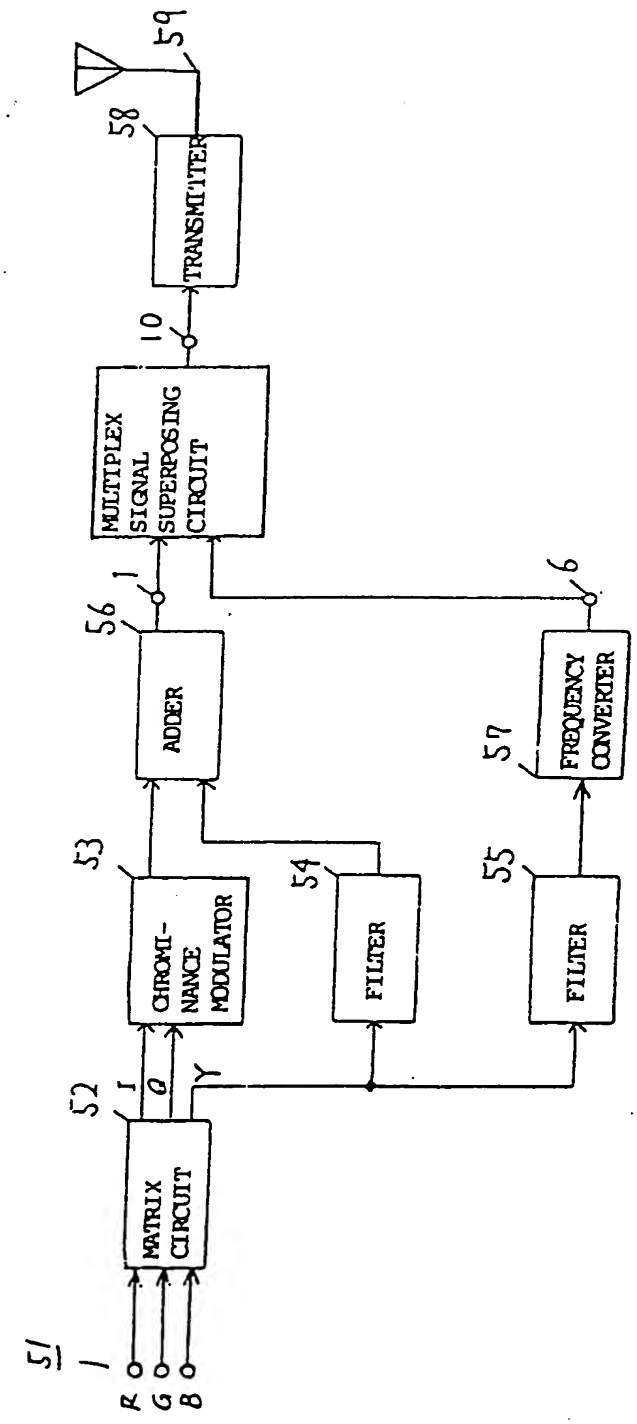

R
G
B
51
MATRIX CIRCUIT
52
I
Q
Y
CHROMI-NANCE MODULATOR
53
FILTER
54
FILTER
55
ADDER
56
1
FREQUENCY CONVERTER
57
6
MULTIPLEX SIGNAL SUPERPOSING CIRCUIT
10
TRANSMITTER
58
59

FIG. 5 (b)

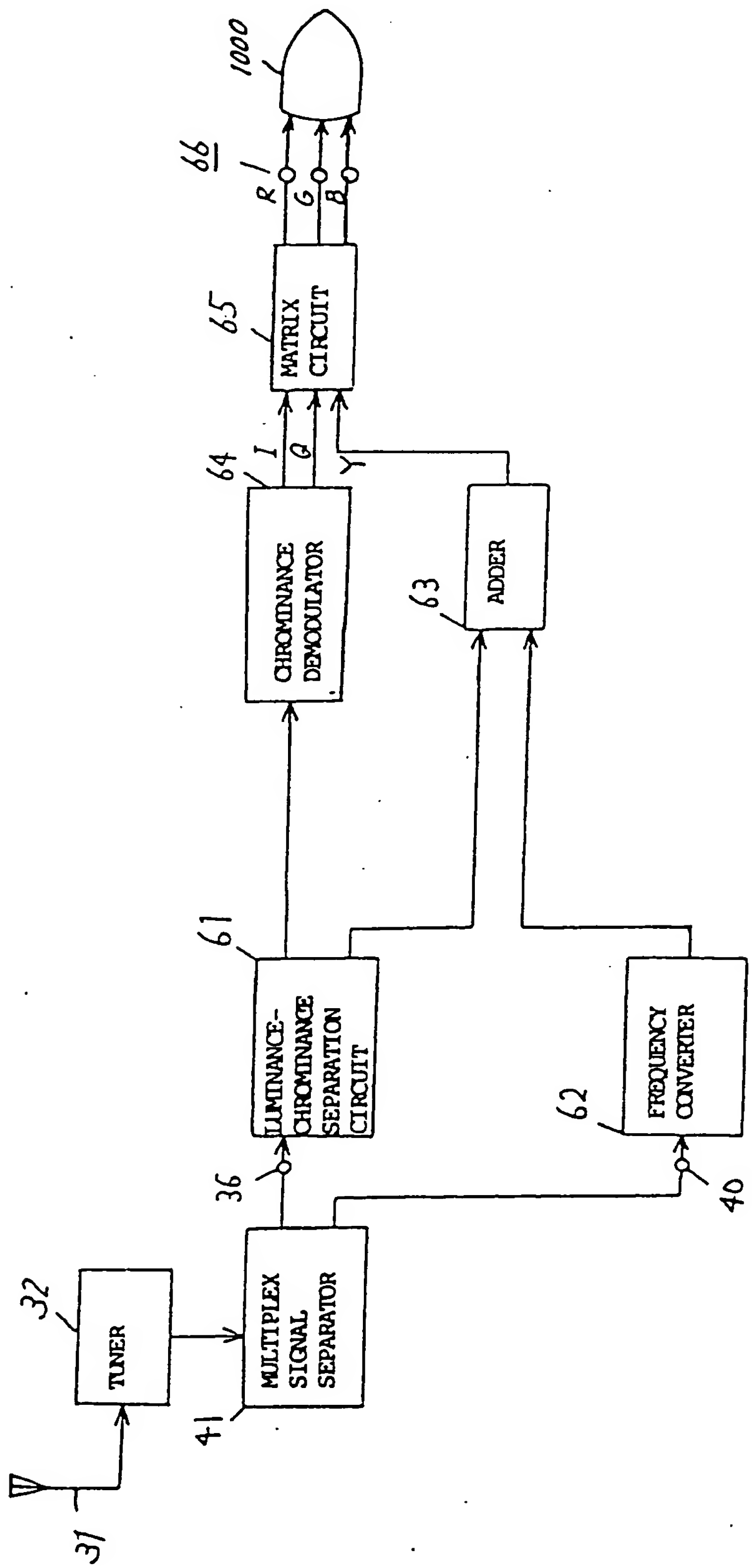

31
32
TUNER
41
MULTIPLEX SIGNAL SEPARATOR
36
40
61
LUMINANCE-CHROMINANCE SEPARATION CIRCUIT
62
FREQUENCY CONVERTER
63
ADDER
64
CHROMINANCE DEMODULATOR
I
Q
Y
65
MATRIX CIRCUIT
66
R
G
B
1000

FIG. 6 (a)

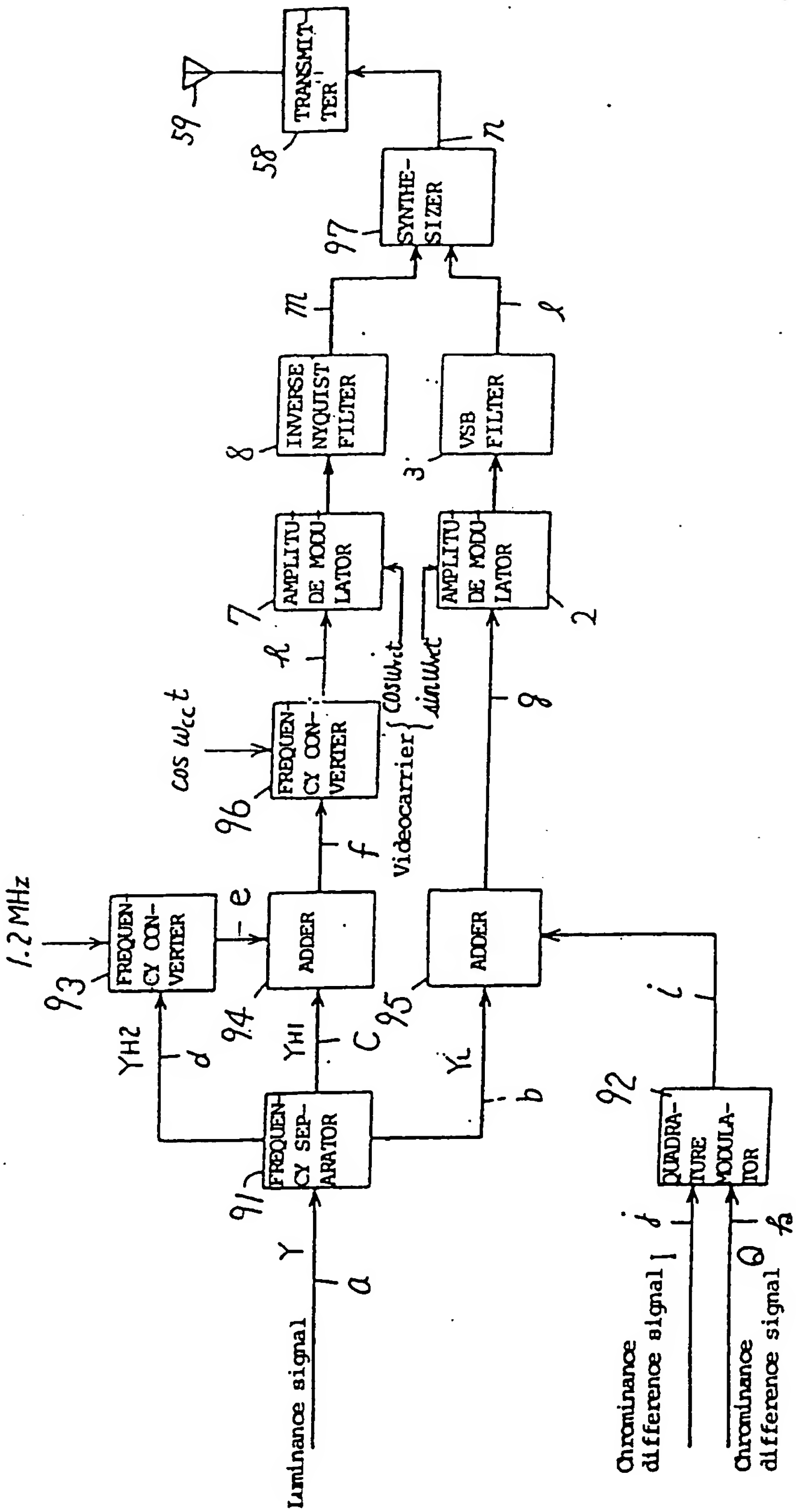

Luminance signal
Y
a
91
FREQUENCY SEPARATOR
YH2
d
YH1
c
YL
b
93
1.2 MHz
FREQUENCY CONVERTER
e
94
ADDER
95
ADDER
f
96
cos ω_cc t
FREQUENCY CONVERTER
Videocarrier
cos ω_c t
sin ω_c t
h
g
7
AMPLITUDE MODULATOR
2
AMPLITUDE MODULATOR
8
INVERSE NYQUIST FILTER
3
VSB FILTER
m
l
97
SYNTHESIZER
n
58
TRANSMITTER
59
92
QUADRATURE MODULATOR
i
Chrominance difference signal I
j
Chrominance difference signal Q
k

FIG. 6 (b)

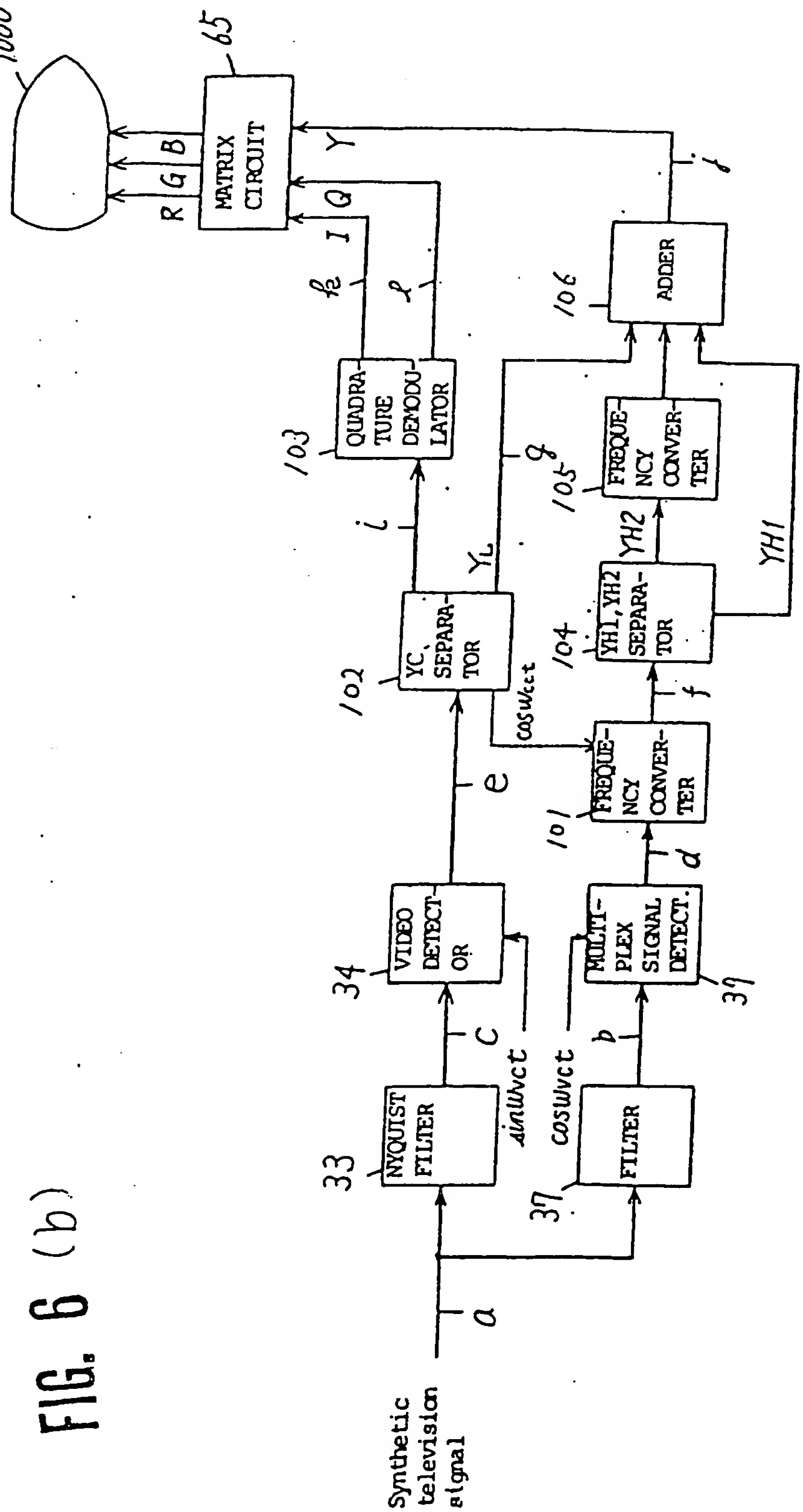
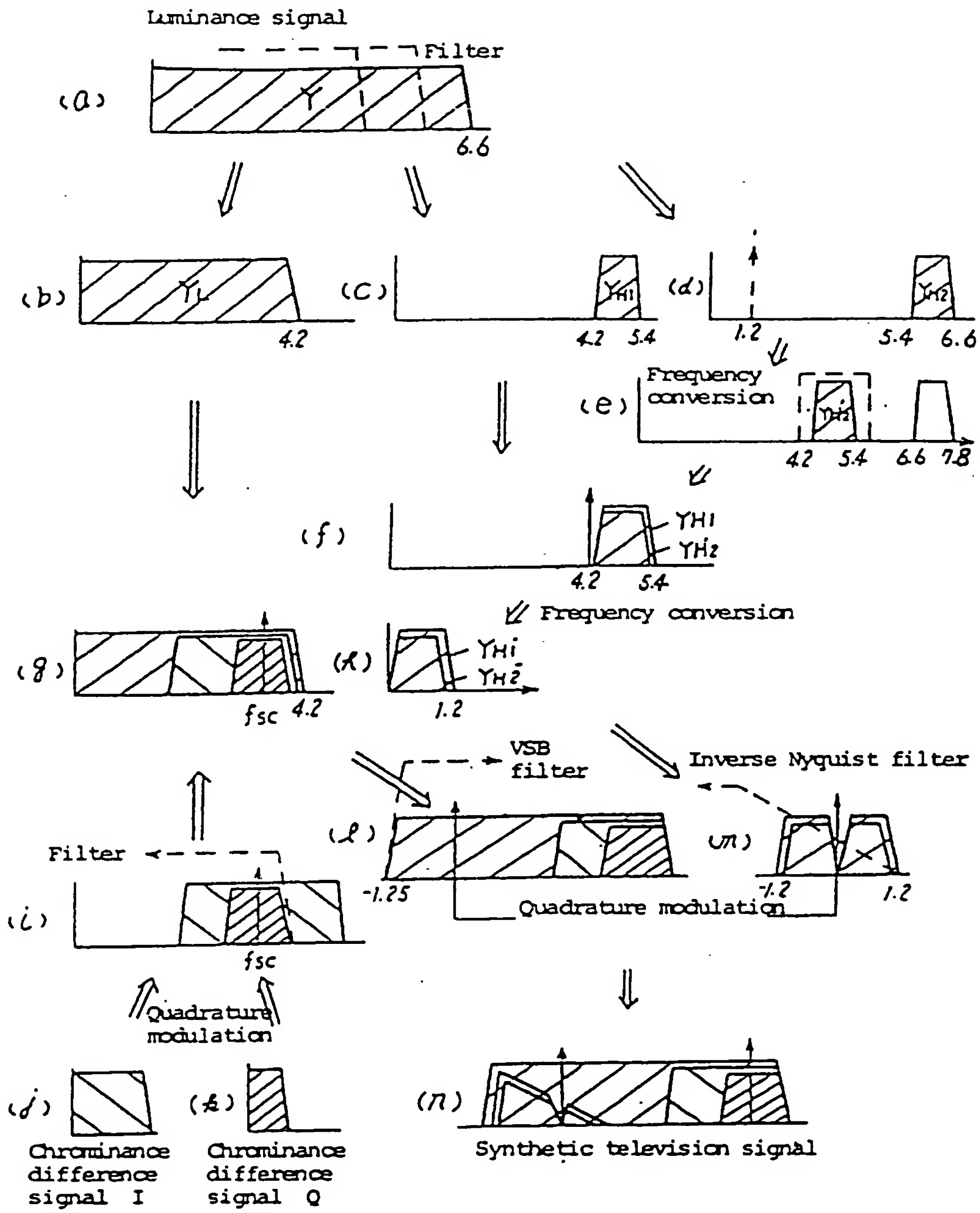

Synthetic television signal
a
33
NYQUIST FILTER
37
FILTER
c
b
sinωct
cosωct
34
VIDEO DETECTOR
39
MULTIPLEX SIGNAL DETECT.
e
d
101
FREQUENCY CONVERTER
102
YC SEPARATOR
cosωcct
f
104
YH1, YH2 SEPARATOR
YH1
YH2
105
FREQUENCY CONVERTER
YL
g
i
103
QUADRATURE DEMODULATOR
106
ADDER
j
65
MATRIX CIRCUIT
I
Q
Y
R
G
B
1000

FIG. 7



Luminance signal
Filter
(a)
Y
6.6
(b)
YL
4.2
(c)
YH1
4.2 5.4
(d)
1.2
YH2
5.4 6.6
Frequency conversion
(e)
YH2
4.2 5.4 6.6 7.8
(f)
YH1
YH2
4.2 5.4
Frequency conversion
(g)
fsc 4.2
(h)
YH1
YH2
1.2
VSB filter
Inverse Nyquist filter
(l)
-1.25
(m)
-1.2 1.2
Quadrature modulation
Filter
(i)
fsc
Quadrature modulation
(j)
(k)
Chrominance difference signal I
Chrominance difference signal Q
(n)
Synthetic television signal

FIG. 8

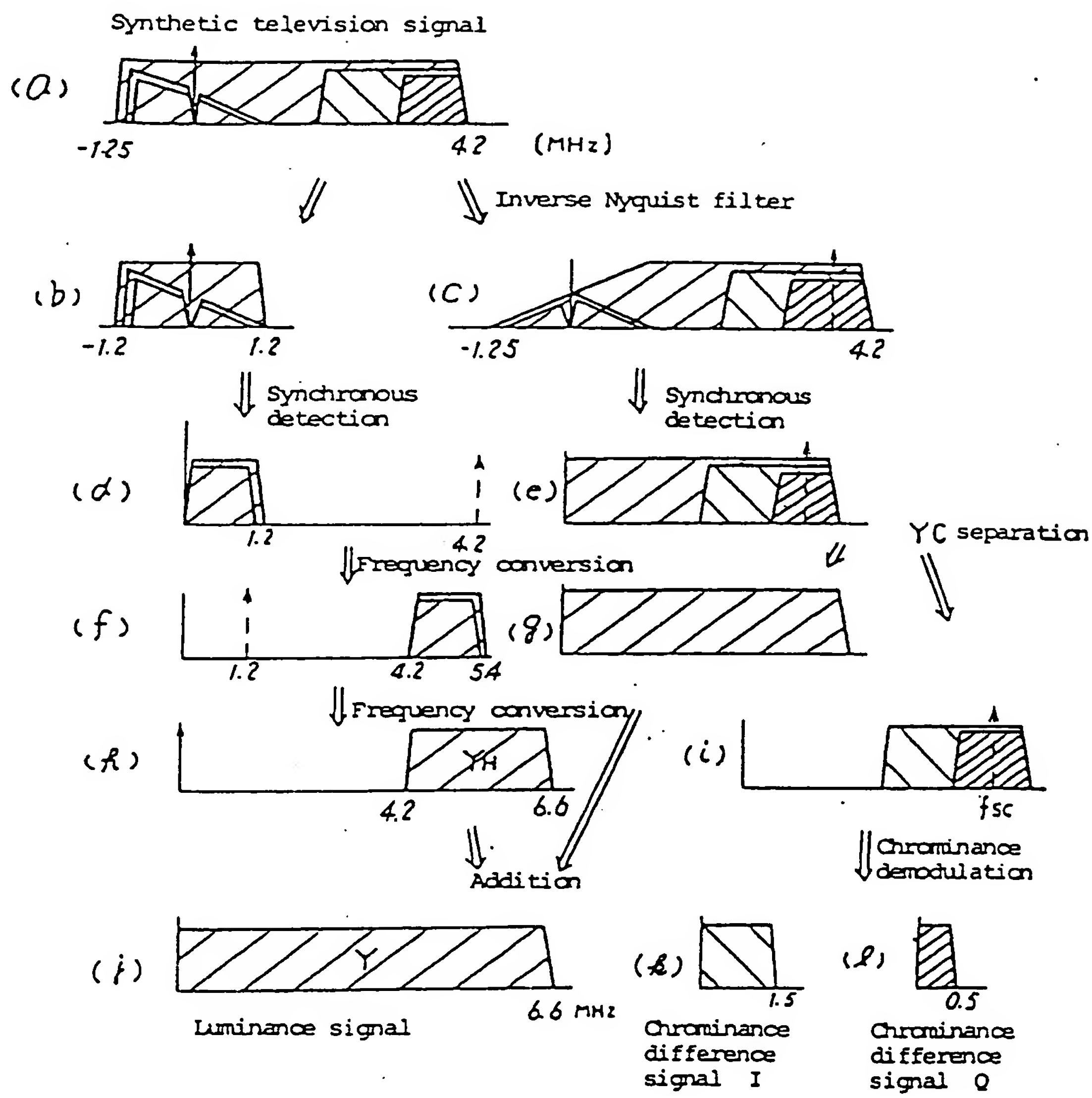

Synthetic television signal
(a)
-1.25
4.2
(MHz)
Inverse Nyquist filter
(b)
-1.2
1.2
(c)
-1.25
4.2
Synchronous detection
Synchronous detection
(d)
1.2
4.2
(e)
YC separation
Frequency conversion
(f)
1.2
4.2
5.4
(g)
Frequency conversion
(h)
YH
4.2
6.6
(i)
fsc
Chrominance demodulation
Addition
(j)
Y
6.6 MHz
Luminance signal
(k)
1.5
Chrominance difference signal I
(l)
0.5
Chrominance difference signal Q

FIG. 9 (a)

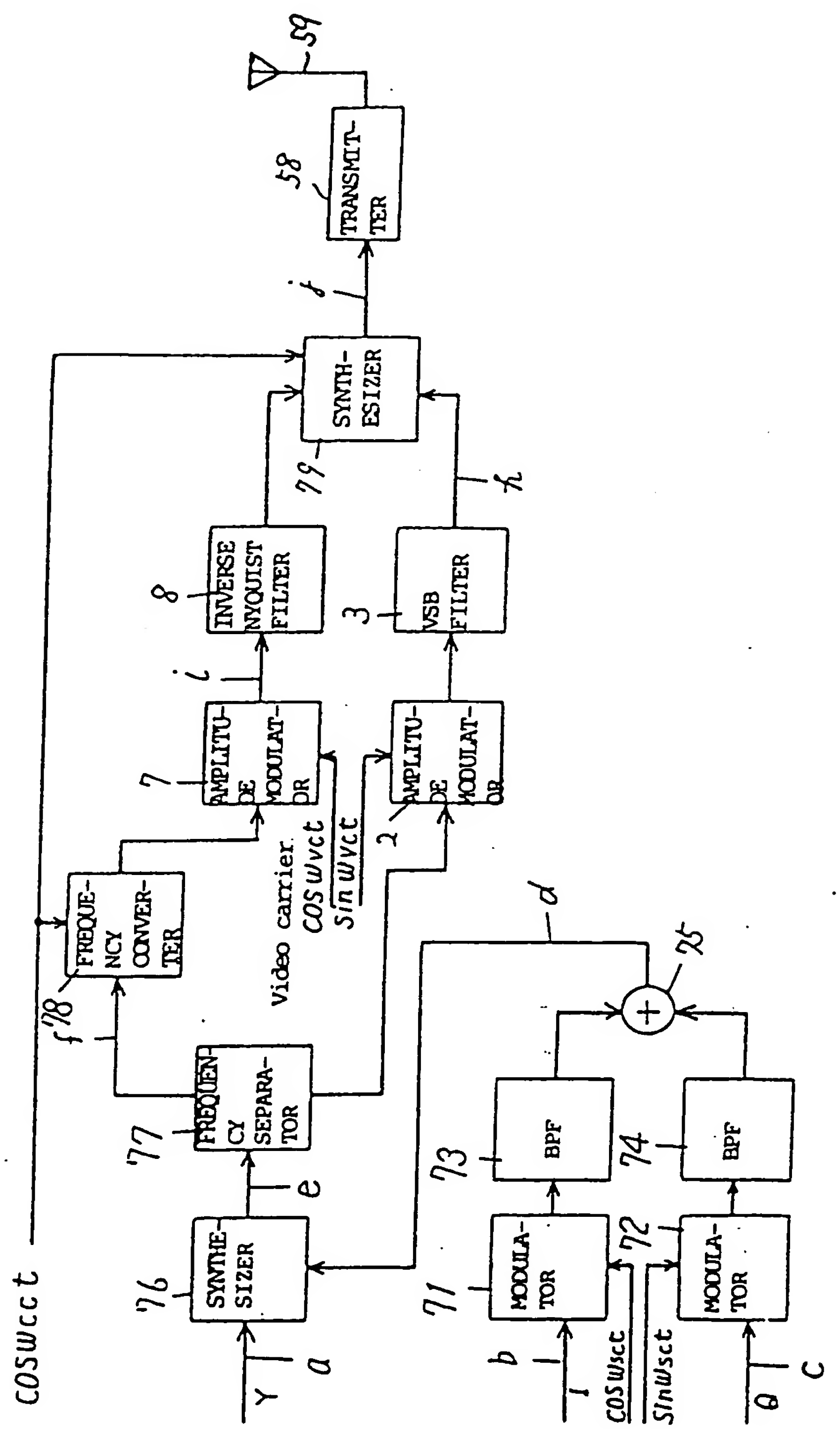

59
58
TRANSMIT-TER
j
SYNTH-ESIZER
79
h
8
INVERSE NYQUIST FILTER
3
VSB FILTER
i
7
AMPLITU-DE MODULAT-OR
2
AMPLITU-DE MODULAT-OR
video carrier
cos ωvct
sin ωvct
78
FREQUE-NCY CONVER-TER
f
77
FREQUEN-CY SEPARA-TOR
e
76
SYNTHE-SIZER
cos ωcct
Y
a
d
75
73
BPF
74
BPF
71
MODULA-TOR
72
MODULA-TOR
b
I
cos ωsct
sin ωsct
Q
c

FIG. 9 (b)

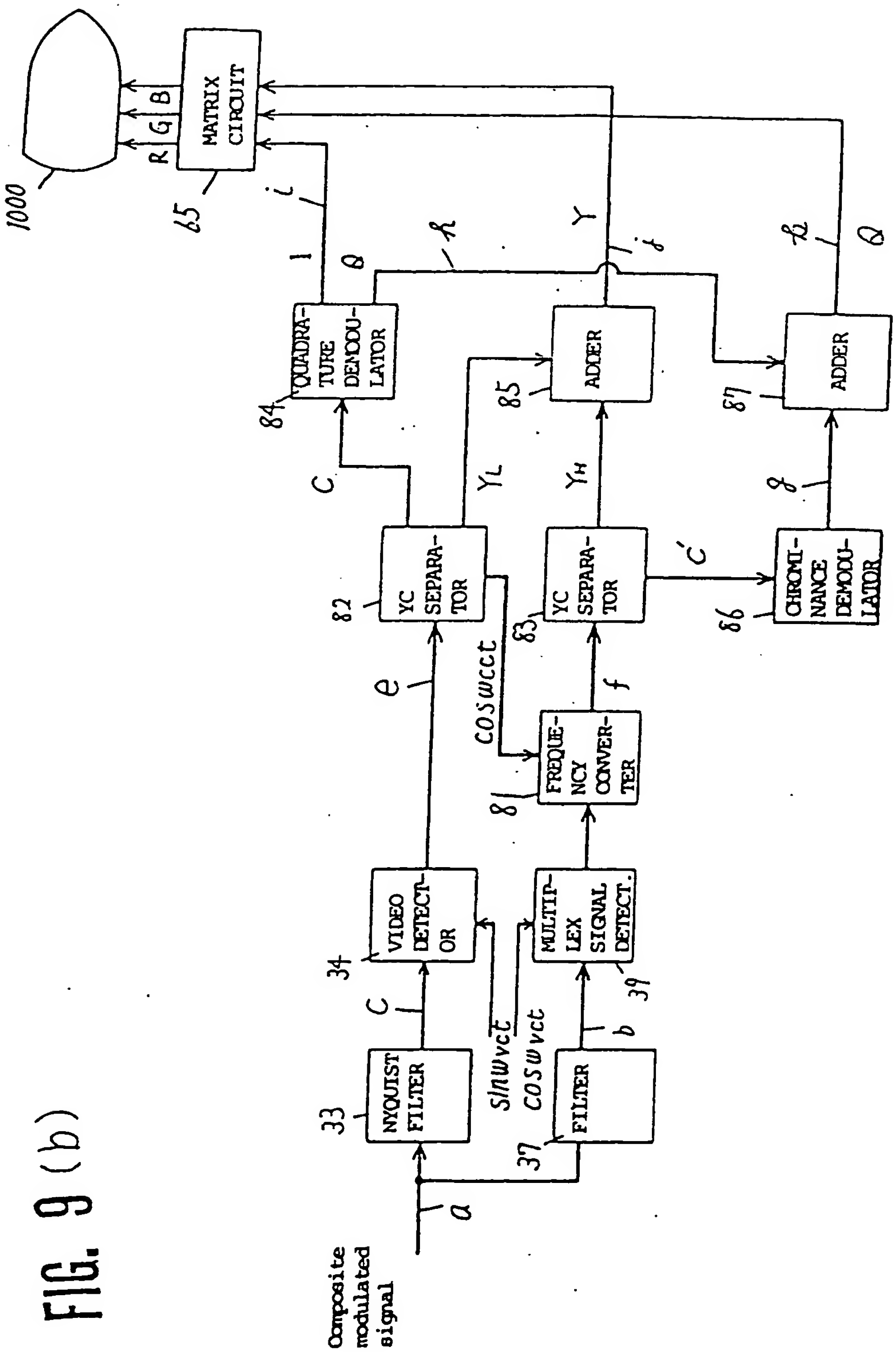

Composite modulated signal
NYQUIST FILTER
FILTER
VIDEO DETECT-OR
MULTIP-LEX SIGNAL DETECT.
FREQUE-NCY CONVER-TER
YC SEPARA-TOR
YC SEPARA-TOR
QUADRA-TURE DEMODU-LATOR
ADDER
ADDER
CHROMI-NANCE DEMODU-LATOR
MATRIX CIRCUIT
R
G
B
Y
Q
I
33
34
37
39
81
82
83
84
85
86
87
65
1000

FIG. 10

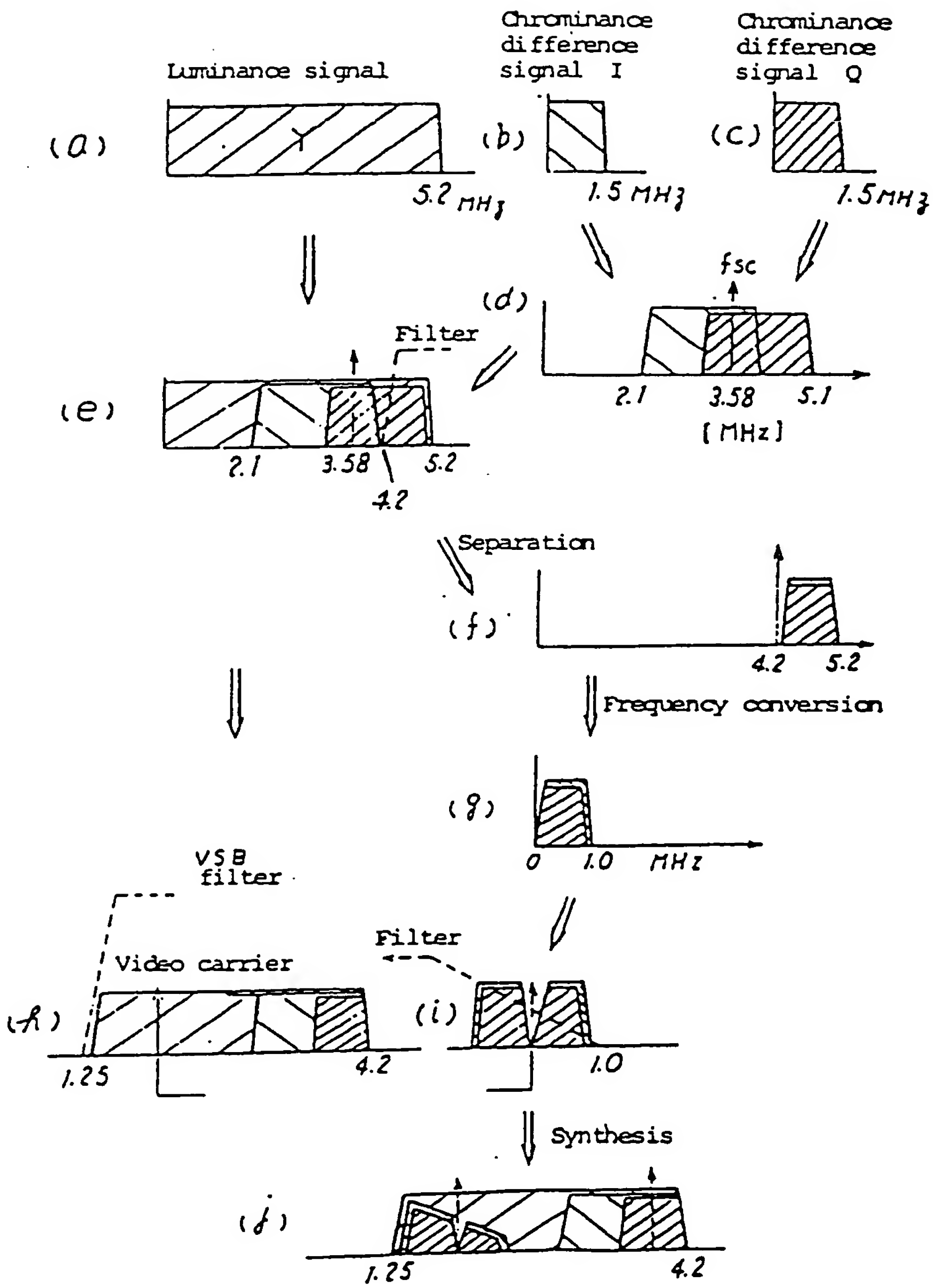
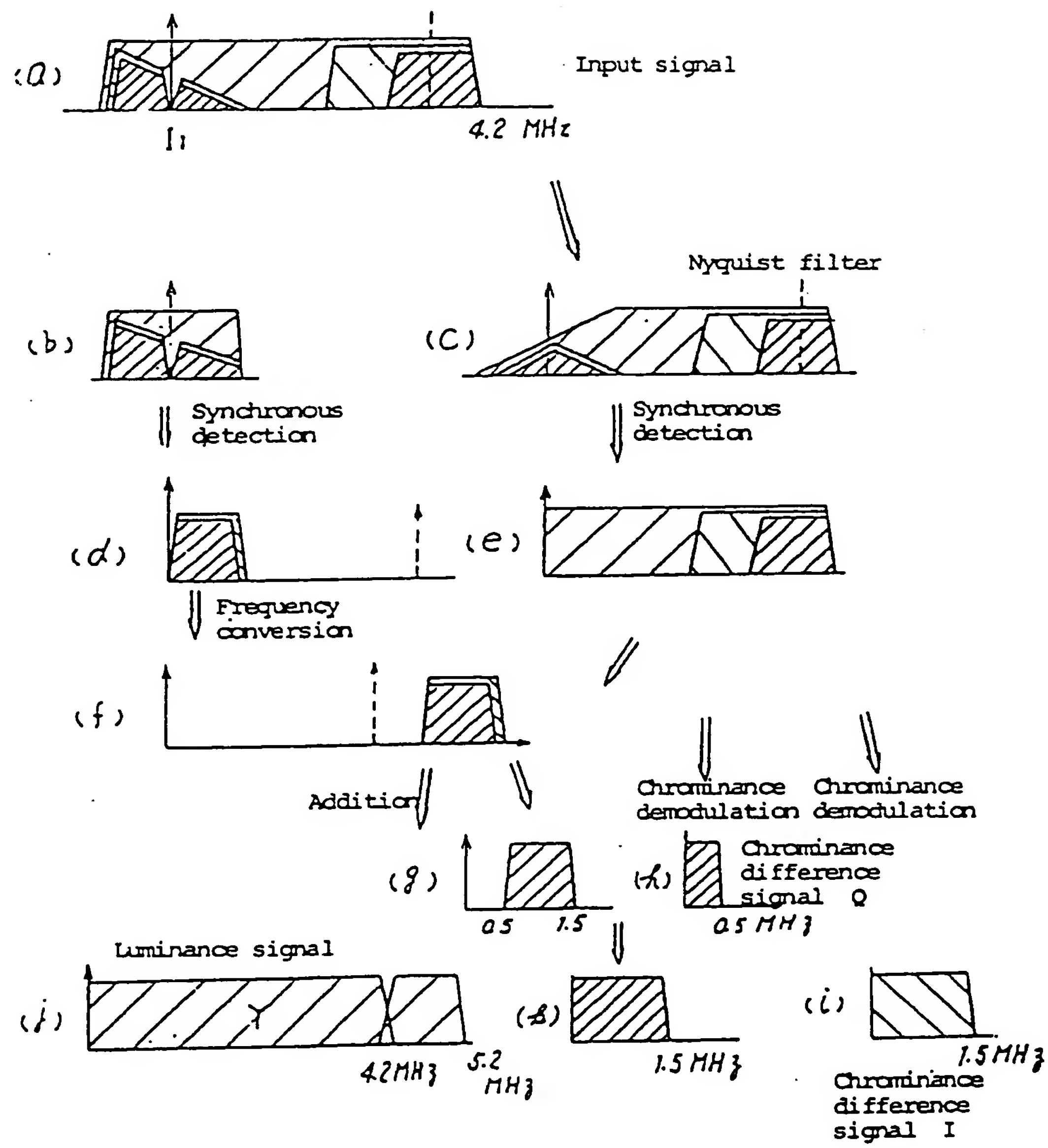
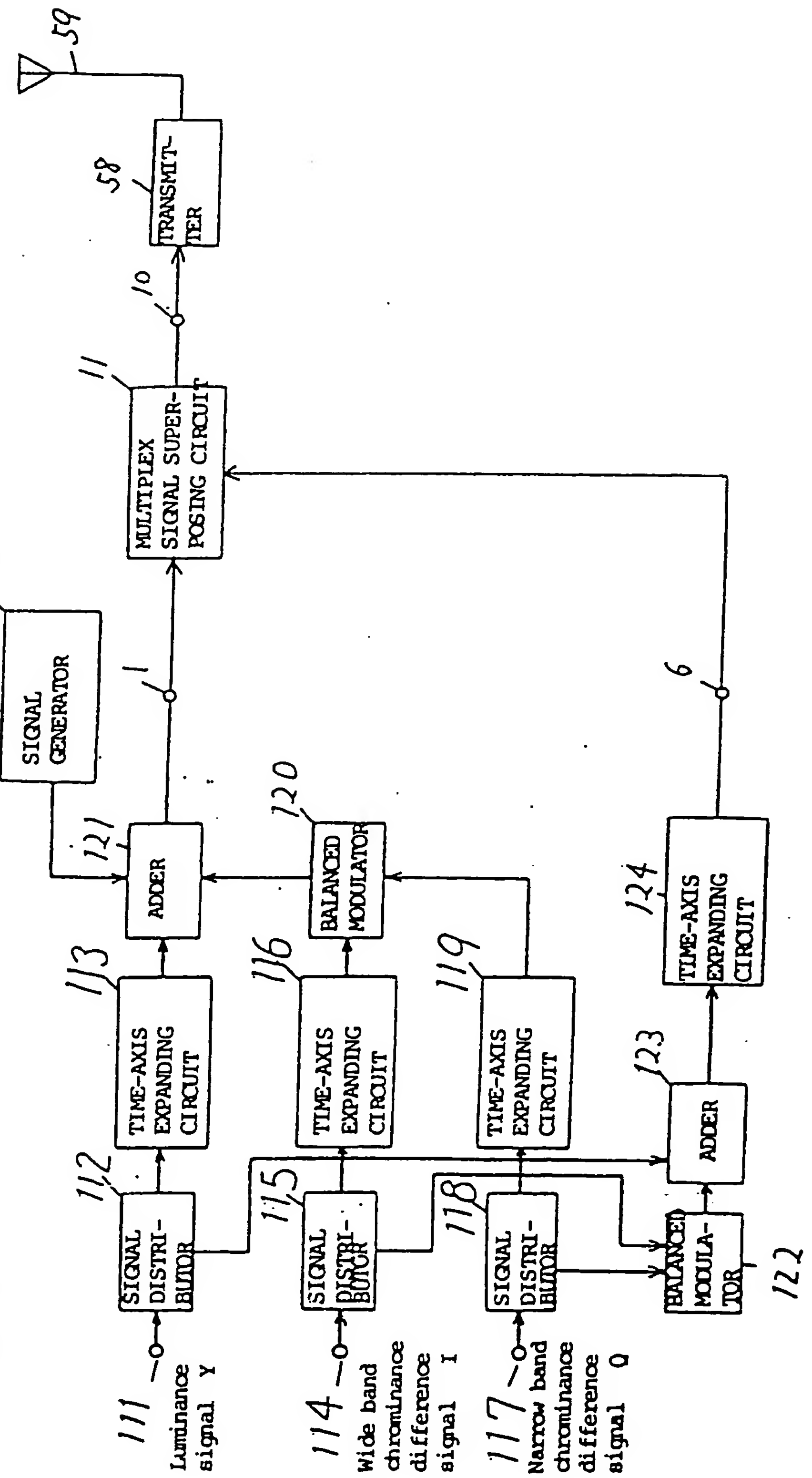

Luminance signal
Chrominance difference signal I
Chrominance difference signal Q
(a)
(b)
(c)
Y
5.2 MHz
1.5 MHz
1.5 MHz
(d)
fsc
2.1
3.58
5.1
[MHz]
Filter
(e)
2.1
3.58
4.2
5.2
Separation
(f)
4.2
5.2
Frequency conversion
(g)
0
1.0
MHz
VSB filter
Video carrier
Filter
(h)
(i)
1.25
4.2
1.0
Synthesis
(j)
1.25
4.2

FIG.11


(a)
Input signal
I1
4.2 MHz
Nyquist filter
(b)
(C)
Synchronous detection
Synchronous detection
(d)
(e)
Frequency conversion
(f)
Addition
Chrominance demodulation
Chrominance demodulation
(g)
0.5
1.5
(h)
Chrominance difference signal Q
0.5 MHz
Luminance signal
(j)
4.2MHz
5.2 MHz
(k)
1.5 MHz
(i)
1.5 MHz
Chrominance difference signal I



59
58
TRANSMIT-TER
10
11
MULTIPLEX SIGNAL SUPER-POSING CIRCUIT
125
SIGNAL GENERATOR
1
6
120
BALANCED MODULATOR
121
ADDER
113
TIME-AXIS EXPANDING CIRCUIT
116
TIME-AXIS EXPANDING CIRCUIT
119
TIME-AXIS EXPANDING CIRCUIT
124
TIME-AXIS EXPANDING CIRCUIT
123
ADDER
112
SIGNAL DISTRI-BUTOR
115
SIGNAL DISTRI-BUTOR
118
SIGNAL DISTRI-BUTOR
122
BALANCED MODULA-TOR
111
Luminance signal Y
114
Wide band chrominance difference signal I
117
Narrow band chrominance difference signal Q

FIG.12 (a)

FIG.12 (b)

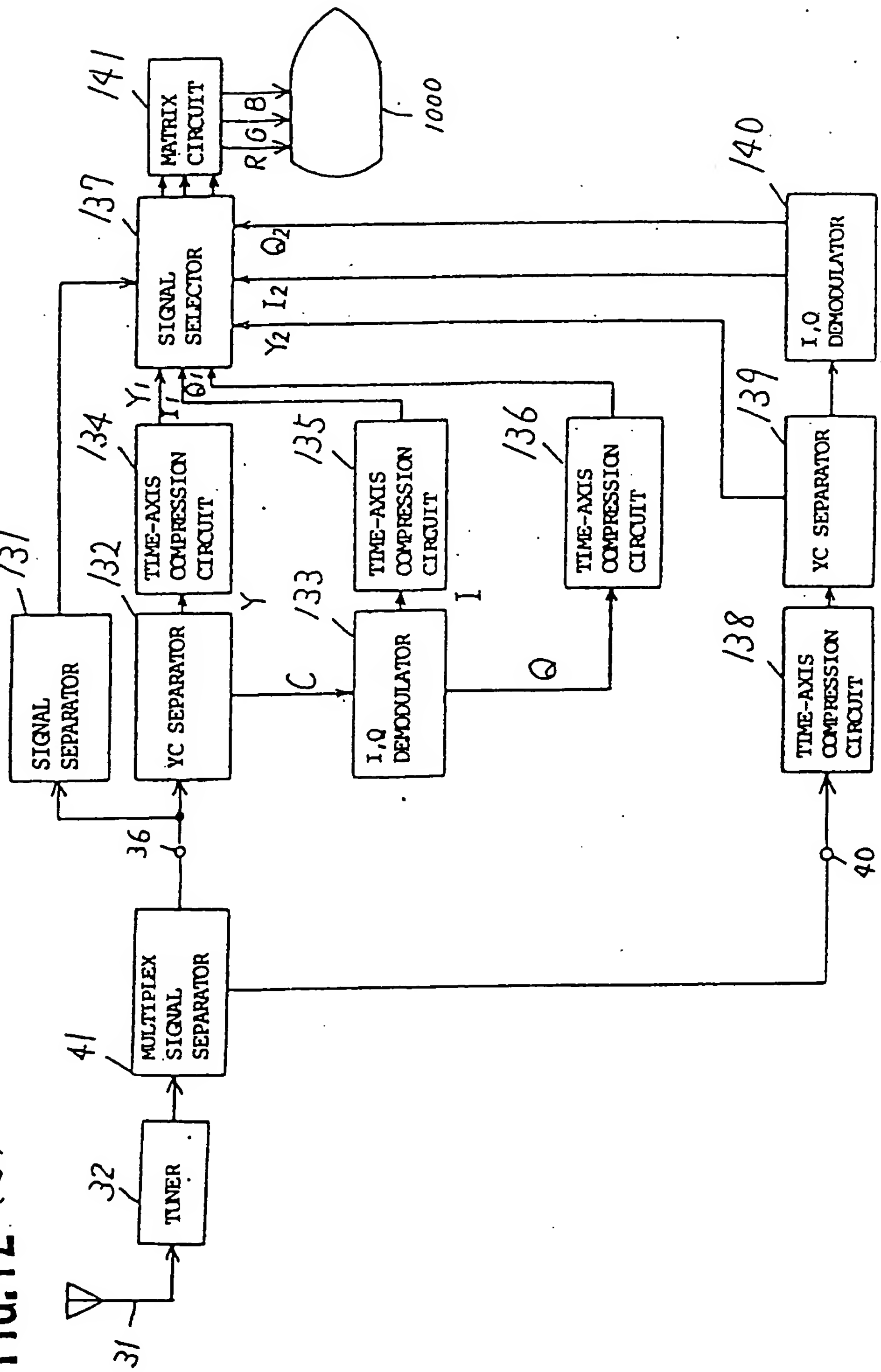

31
TUNER
32
MULTIPLEX SIGNAL SEPARATOR
41
36
40
SIGNAL SEPARATOR
131
YC SEPARATOR
132
I,Q DEMODULATOR
133
C
Y
I
Q
TIME-AXIS COMPRESSION CIRCUIT
134
TIME-AXIS COMPRESSION CIRCUIT
135
TIME-AXIS COMPRESSION CIRCUIT
136
TIME-AXIS COMPRESSION CIRCUIT
138
YC SEPARATOR
139
I,Q DEMODULATOR
140
SIGNAL SELECTOR
137
Y1
I1
Q1
Y2
I2
Q2
MATRIX CIRCUIT
141
R
G
B
1000

FIG.13 (a)

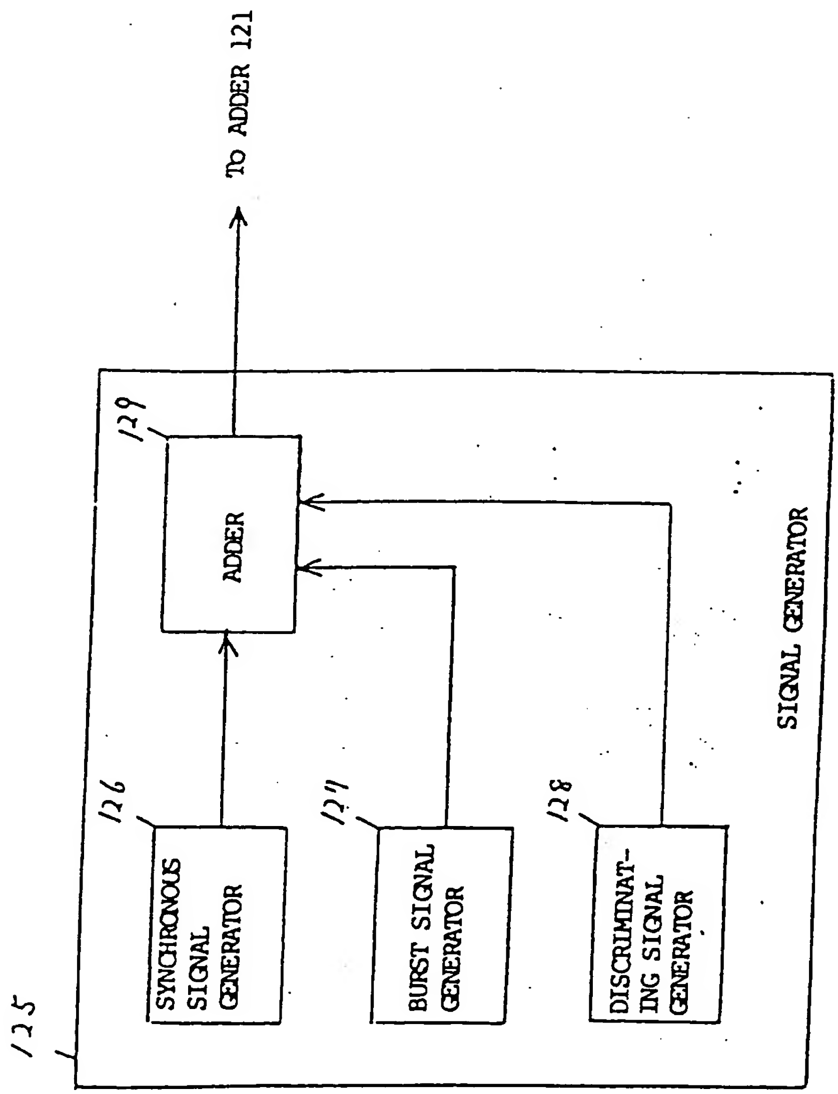

TO ADDER 121
129
ADDER
SIGNAL GENERATOR
126
127
128
SYNCHRONOUS SIGNAL GENERATOR
BURST SIGNAL GENERATOR
DISCRIMINAT-ING SIGNAL GENERATOR
125

FIG. 13 (b)

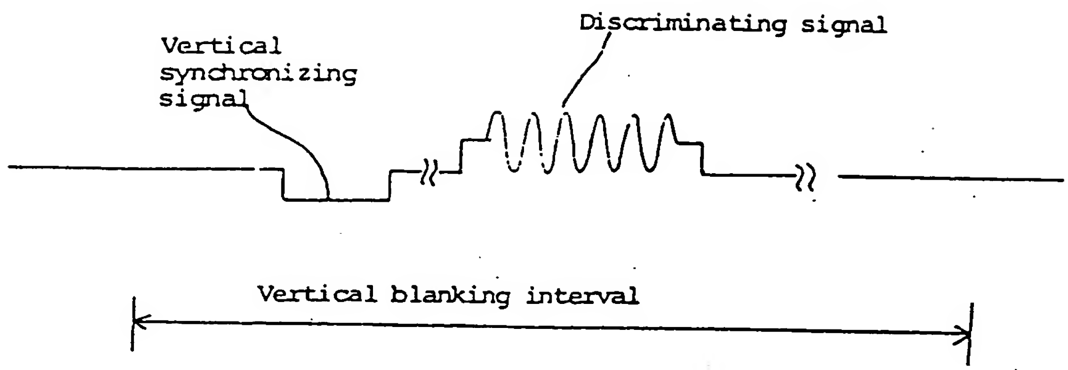

Discriminating signal
Vertical synchronizing signal
Vertical blanking interval

FIG.14

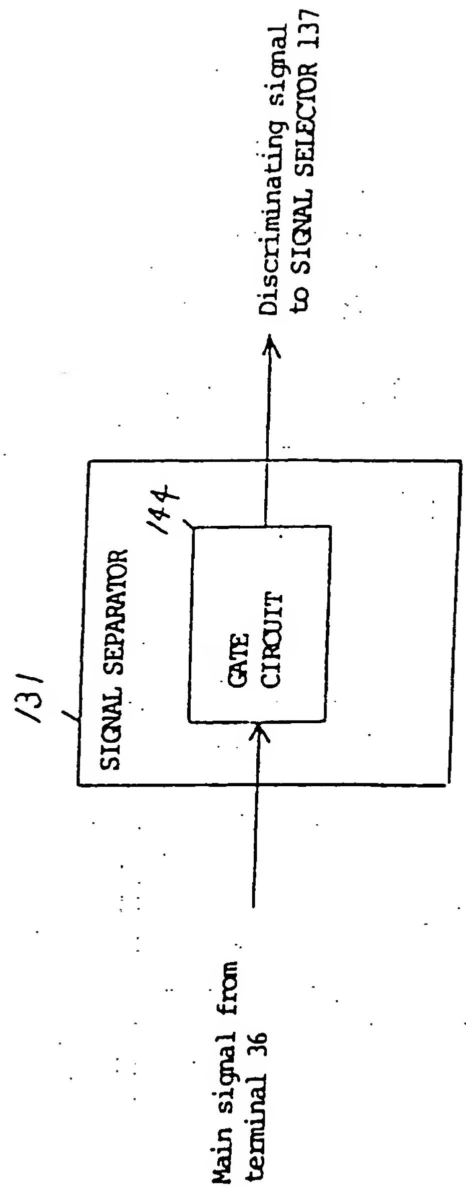
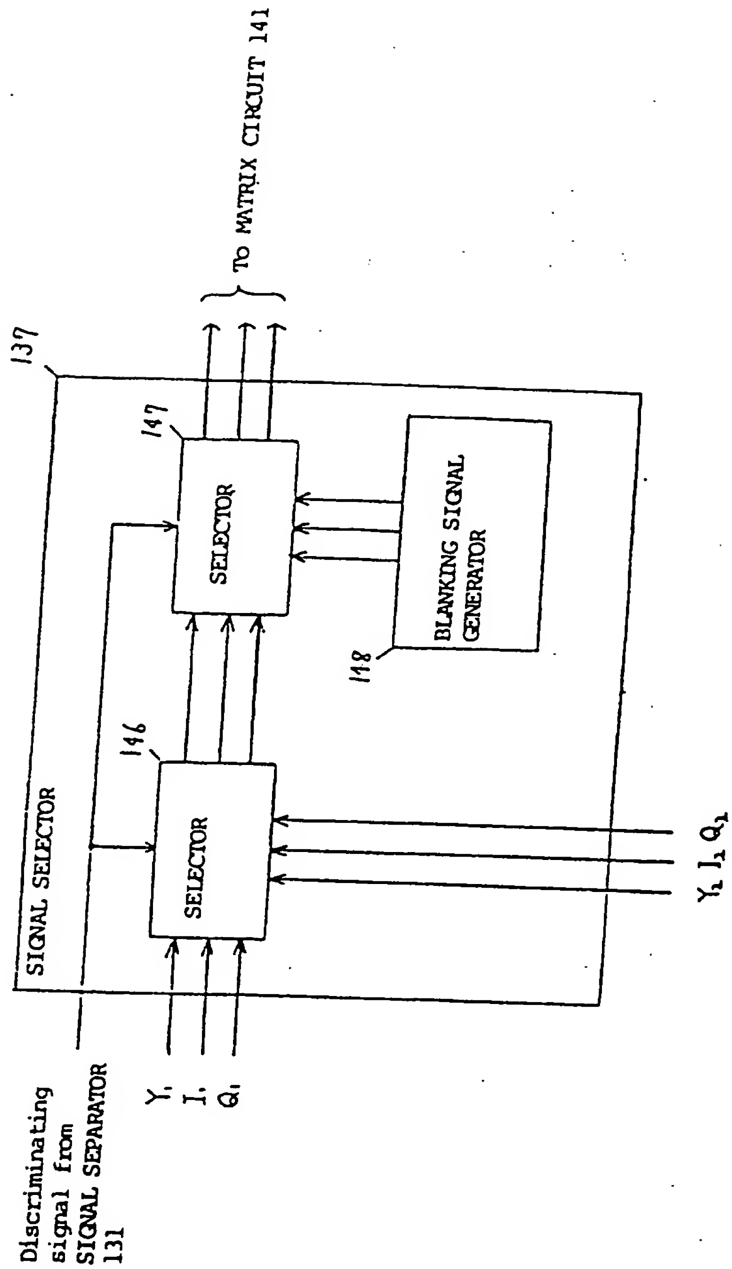

Main signal from terminal 36
131
SIGNAL SEPARATOR
144
GATE CIRCUIT
Discriminating signal to SIGNAL SELECTOR 137

FIG.15



TO MATRIX CIRCUIT 141
137
SIGNAL SELECTOR
146
SELECTOR
147
SELECTOR
148
BLANKING SIGNAL GENERATOR
Discriminating signal from SIGNAL SEPARATOR 131
Y1 I1 Q1
Y2 I2 Q2

FIG.16

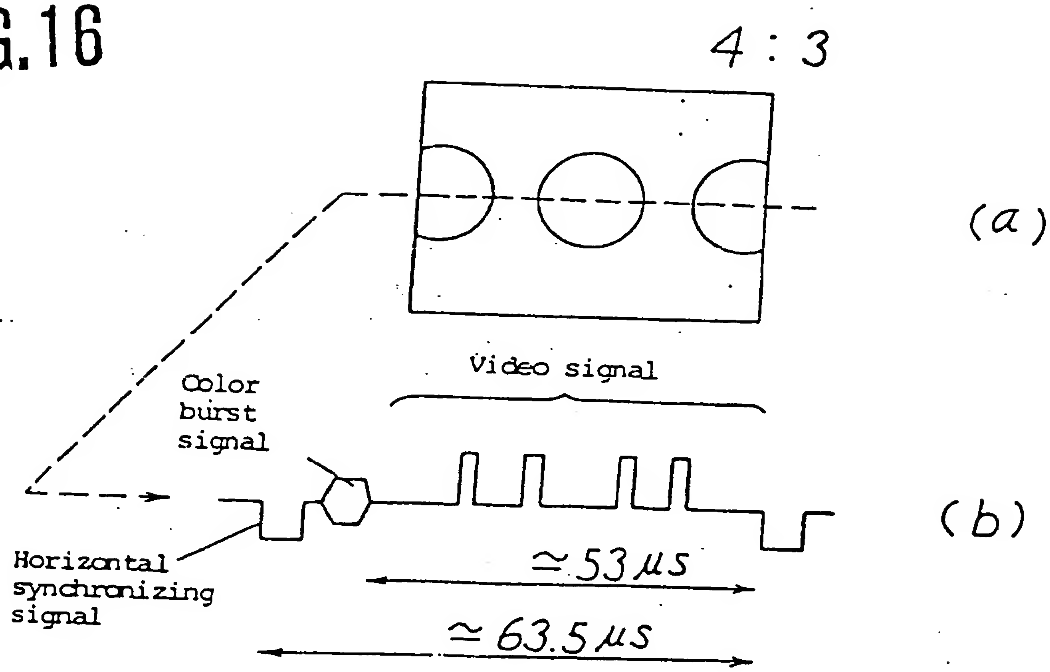

4 : 3
(a)
Video signal
Color burst signal
(b)
Horizontal synchronizing signal
≃ 53 μs
≃ 63.5 μs

FIG.17

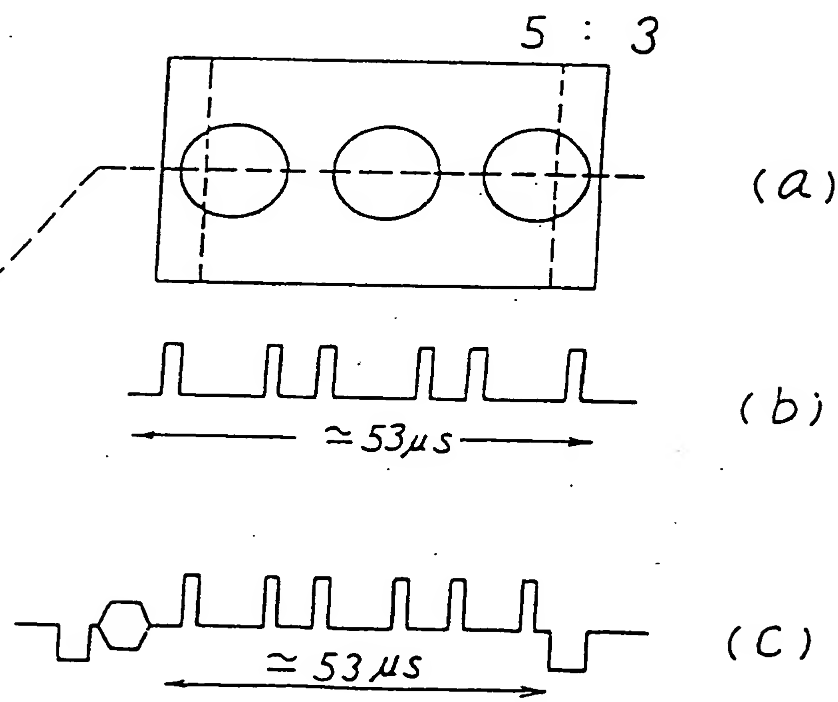
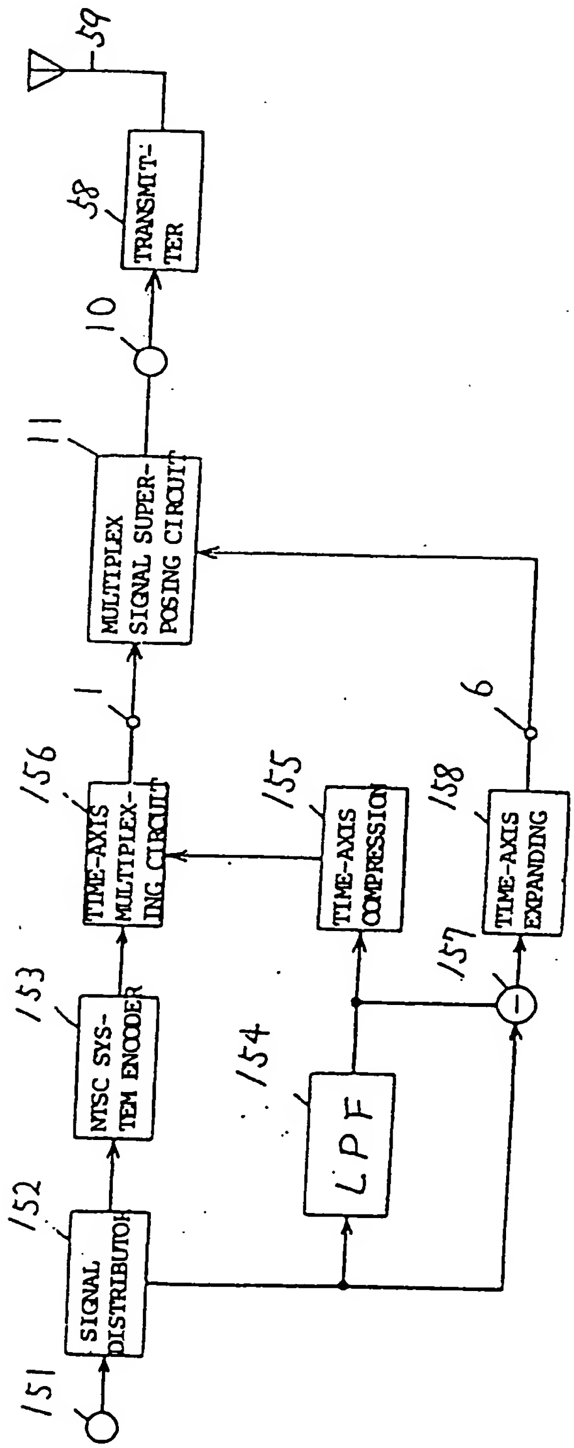

5 : 3
(a)
(b)
≃ 53μs
(c)
≃ 53 μs

FIG.18



151
SIGNAL DISTRIBUTOR
152
NTSC SYS-TEM ENCODER
153
TIME-AXIS MULTIPLEX-ING CIRCUIT
156
1
MULTIPLEX SIGNAL SUPER-POSING CIRCUIT
11
10
TRANSMIT-TER
58
59
LPF
154
TIME-AXIS COMPRESSION
155
157
TIME-AXIS EXPANDING
158
6

FIG.19

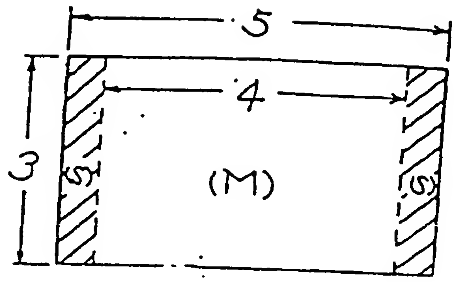

5
4
3
(S)
(M)
(S)

FIG.20

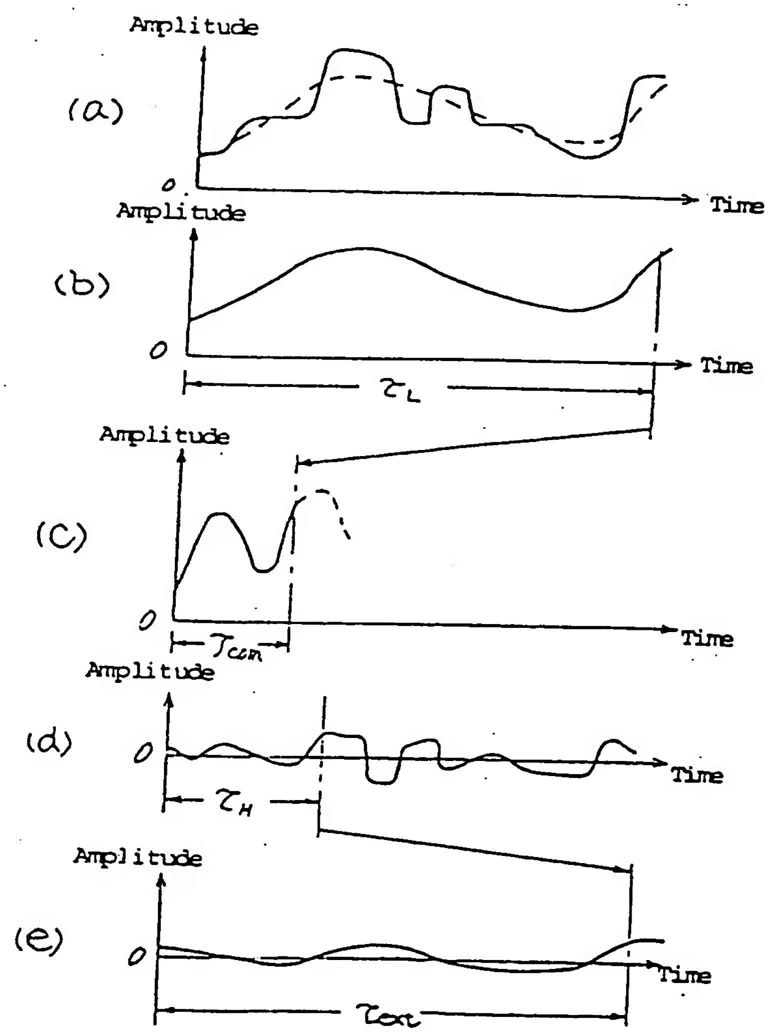

Amplitude
(a)
0
Time
Amplitude
(b)
0
Time
Amplitude
(c)
0
Time
Amplitude
(d)
0
Time
Amplitude
(e)
0
Time

FIG.21

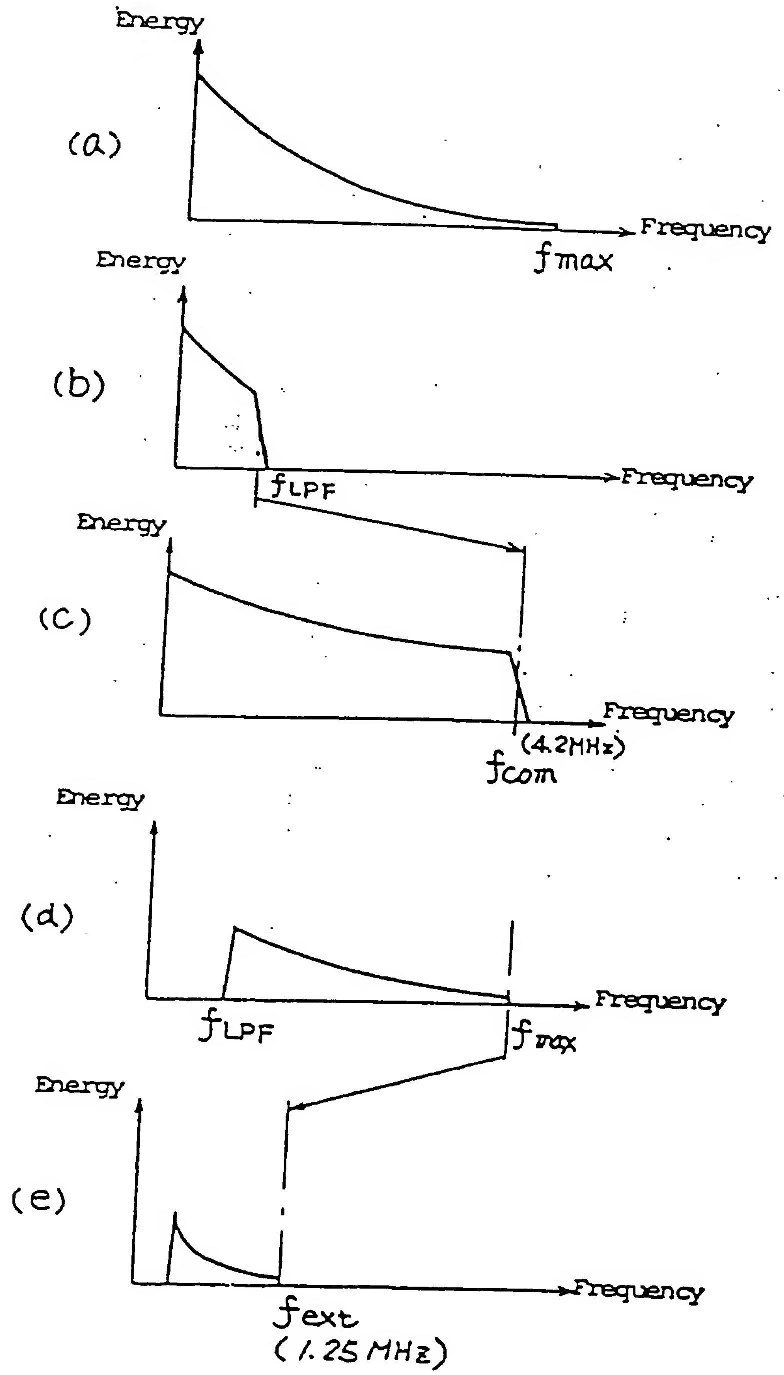

Energy
(a)
Frequency
fmax
Energy
(b)
fLPF
Frequency
Energy
(c)
Frequency
(4.2MHz)
fcom
Energy
(d)
Frequency
fLPF
fmax
Energy
(e)
Frequency
fext
(1.25MHz)

FIG.22

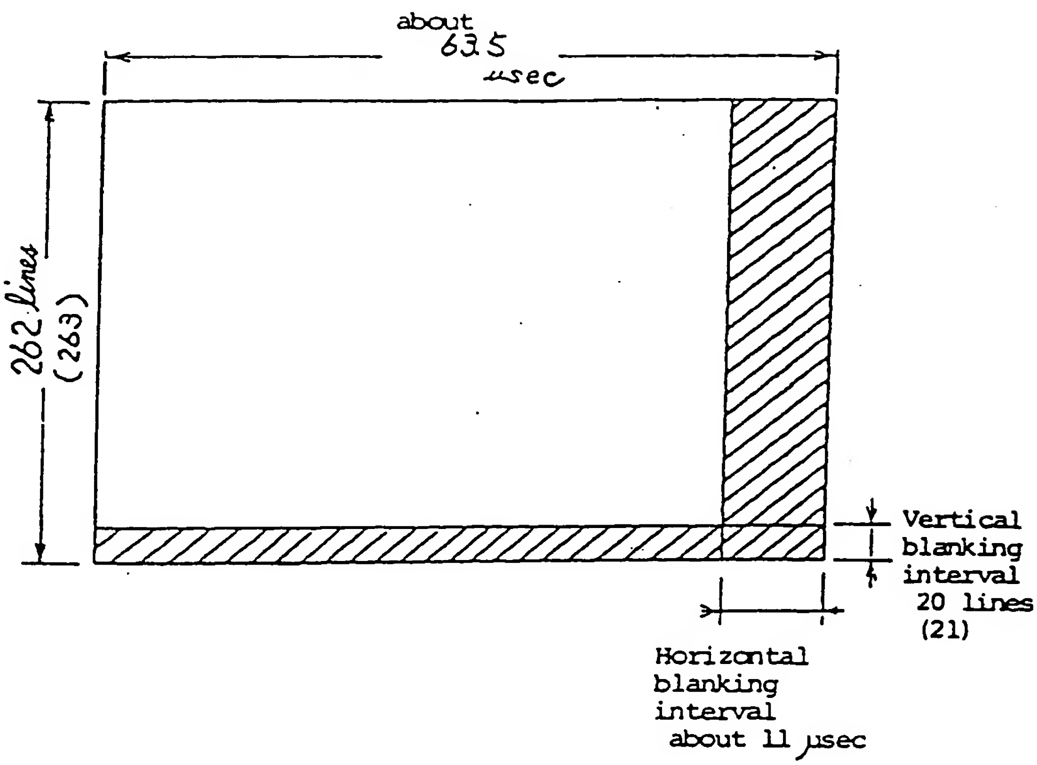

about
63.5
μsec
262 lines
(263)
Vertical
blanking
interval
20 lines
(21)
Horizontal
blanking
interval
about 11 μsec

FIG.23

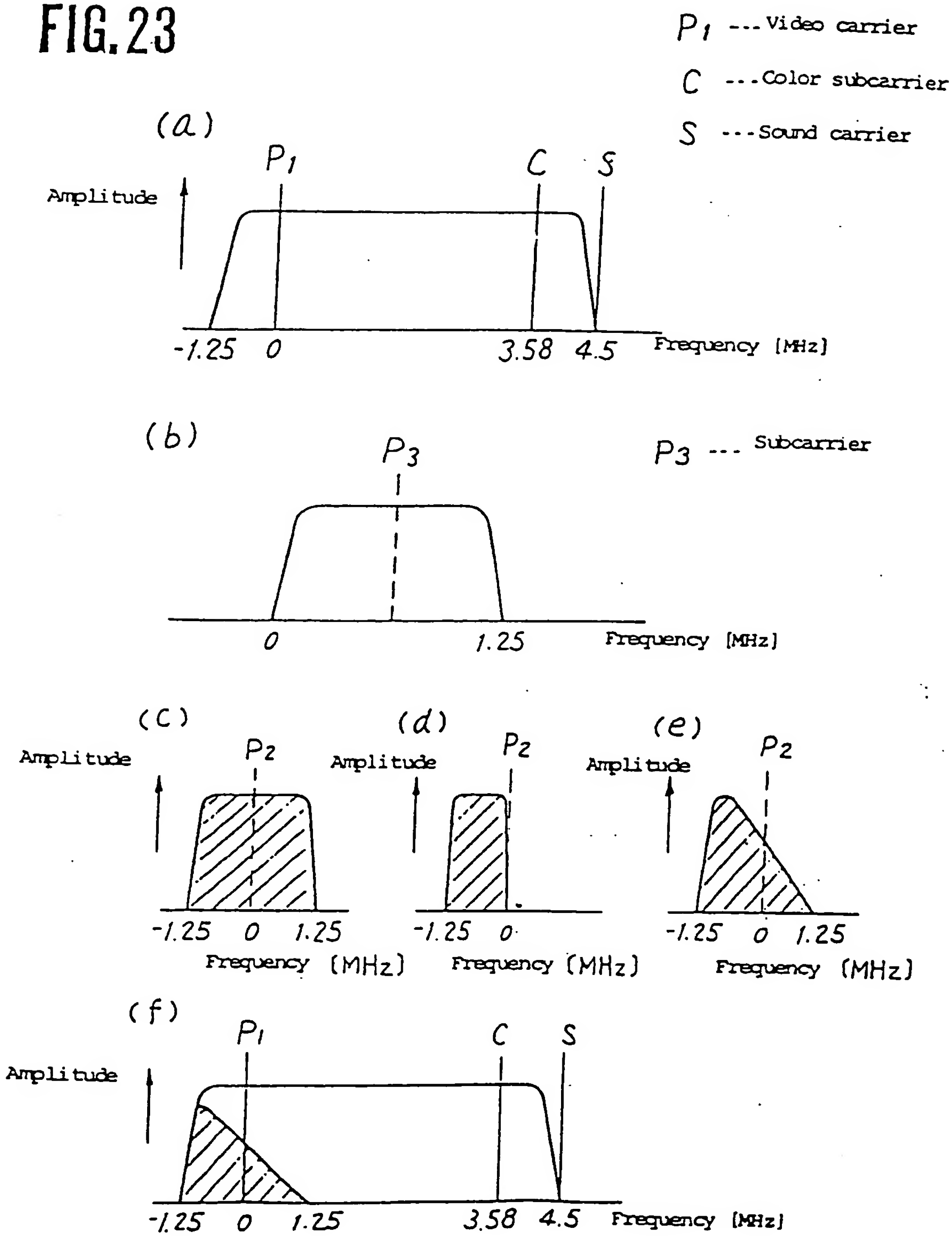

P_1 --- Video carrier
C --- Color subcarrier
S --- Sound carrier
(a)
P_1
C
S
Amplitude
-1.25
0
3.58
4.5
Frequency [MHz]
(b)
P_3
P_3 --- Subcarrier
0
1.25
Frequency [MHz]
(c)
Amplitude
P_2
-1.25
0
1.25
Frequency (MHz)
(d)
Amplitude
P_2
-1.25
0
Frequency (MHz)
(e)
Amplitude
P_2
-1.25
0
1.25
Frequency (MHz)
(f)
P_1
C
S
Amplitude
-1.25
0
1.25
3.58
4.5
Frequency [MHz]

FIG.24

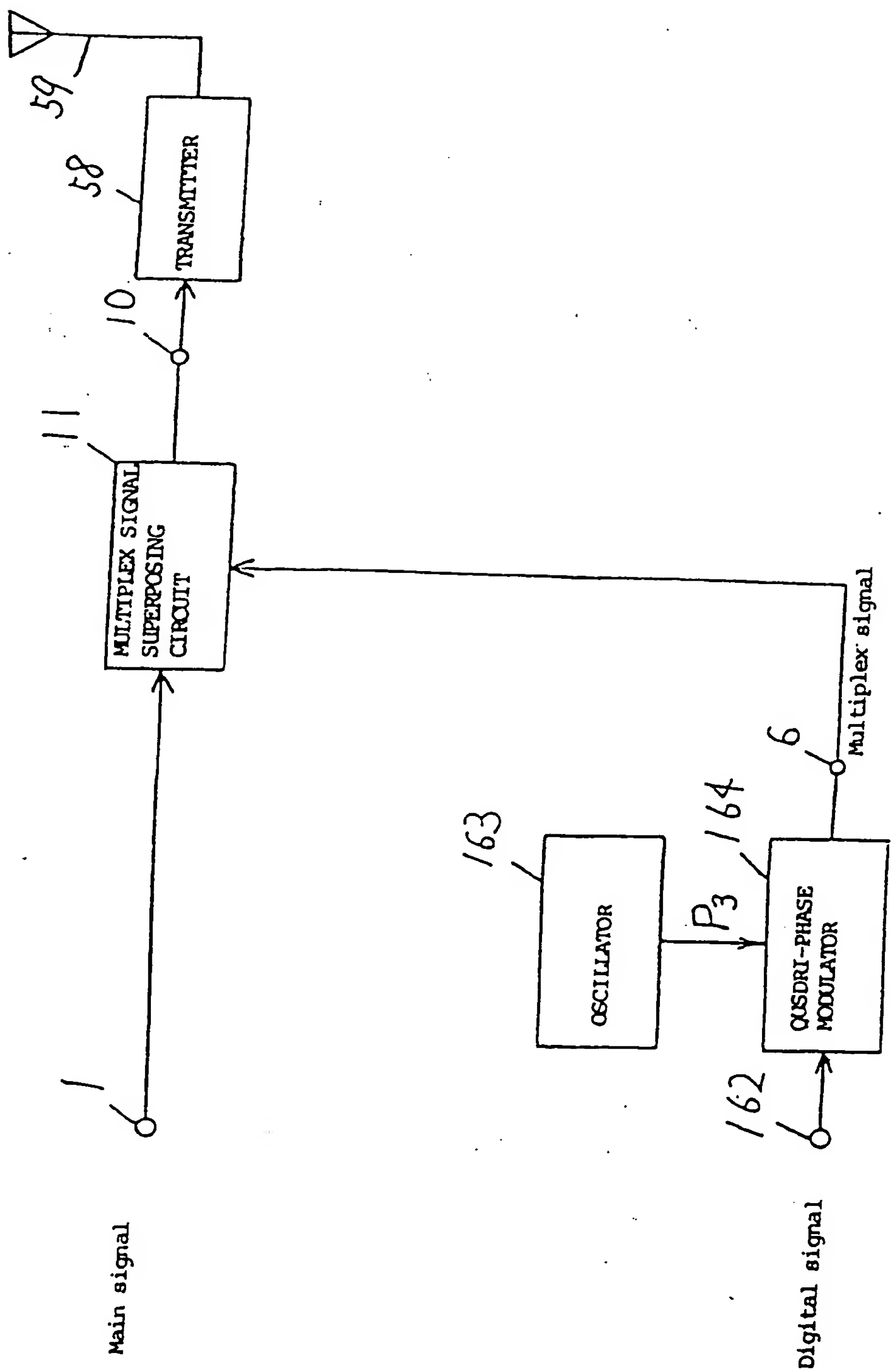

Main signal
1
MULTIPLEX SIGNAL SUPERPOSING CIRCUIT
11
10
TRANSMITTER
58
59
Digital signal
162
OSCILLATOR
163
P3
QUSDRI-PHASE MODULATOR
164
6
Multiplex signal

FIG.25

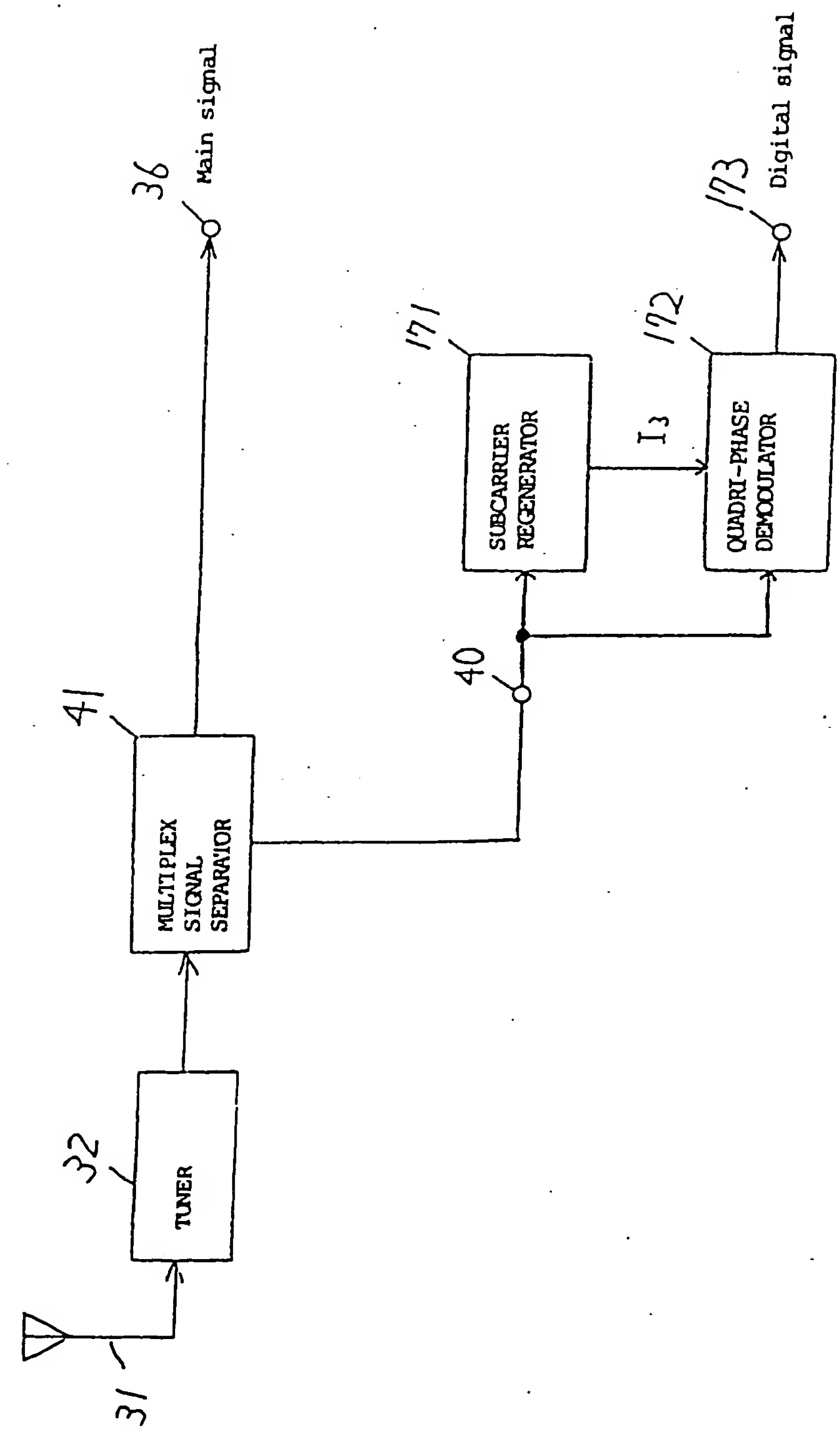

31
32
TUNER
41
MULTIPLEX SIGNAL SEPARATOR
36
Main signal
40
171
SUBCARRIER REGENERATOR
I_3
172
QUADRI-PHASE DEMODULATOR
173
Digital signal

FIG.26

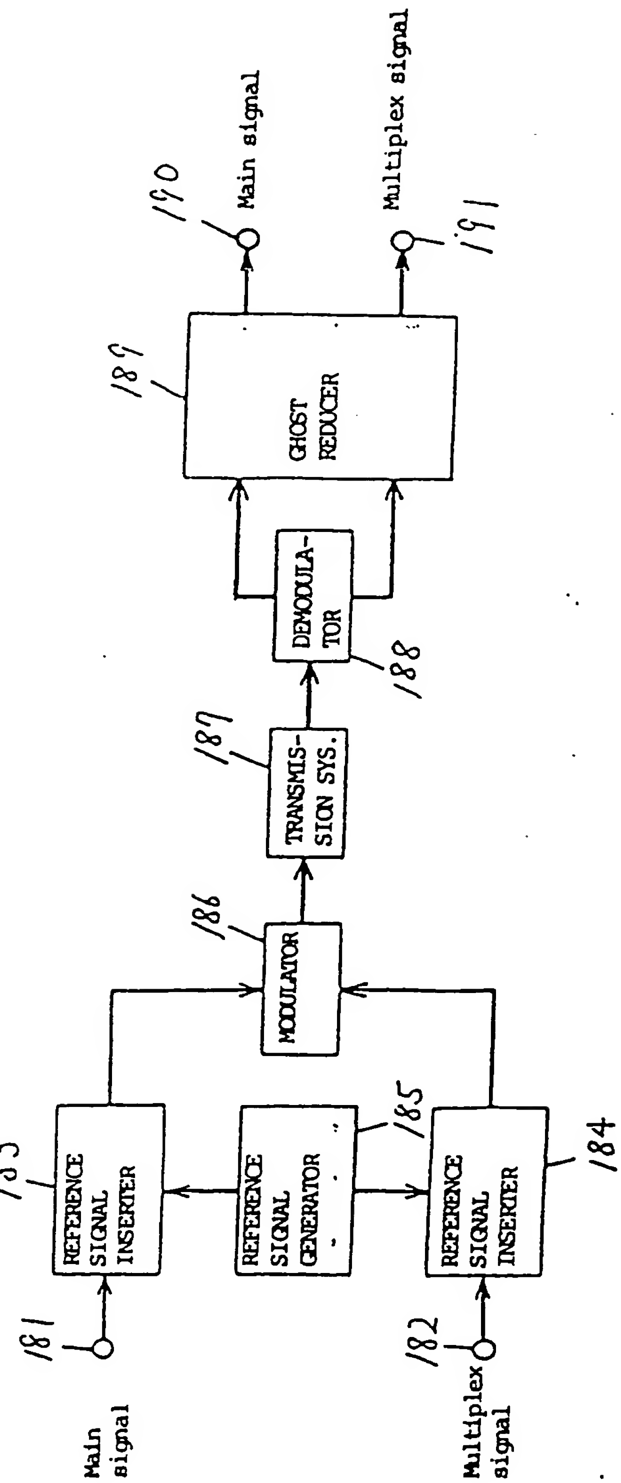

Main signal
181
REFERENCE SIGNAL INSERTER
183
REFERENCE SIGNAL GENERATOR
185
REFERENCE SIGNAL INSERTER
184
Multiplex signal
182
MODULATOR
186
TRANSMISSION SYS.
187
DEMODULATOR
188
GHOST REDUCER
189
Main signal
190
Multiplex signal
191

FIG. 27

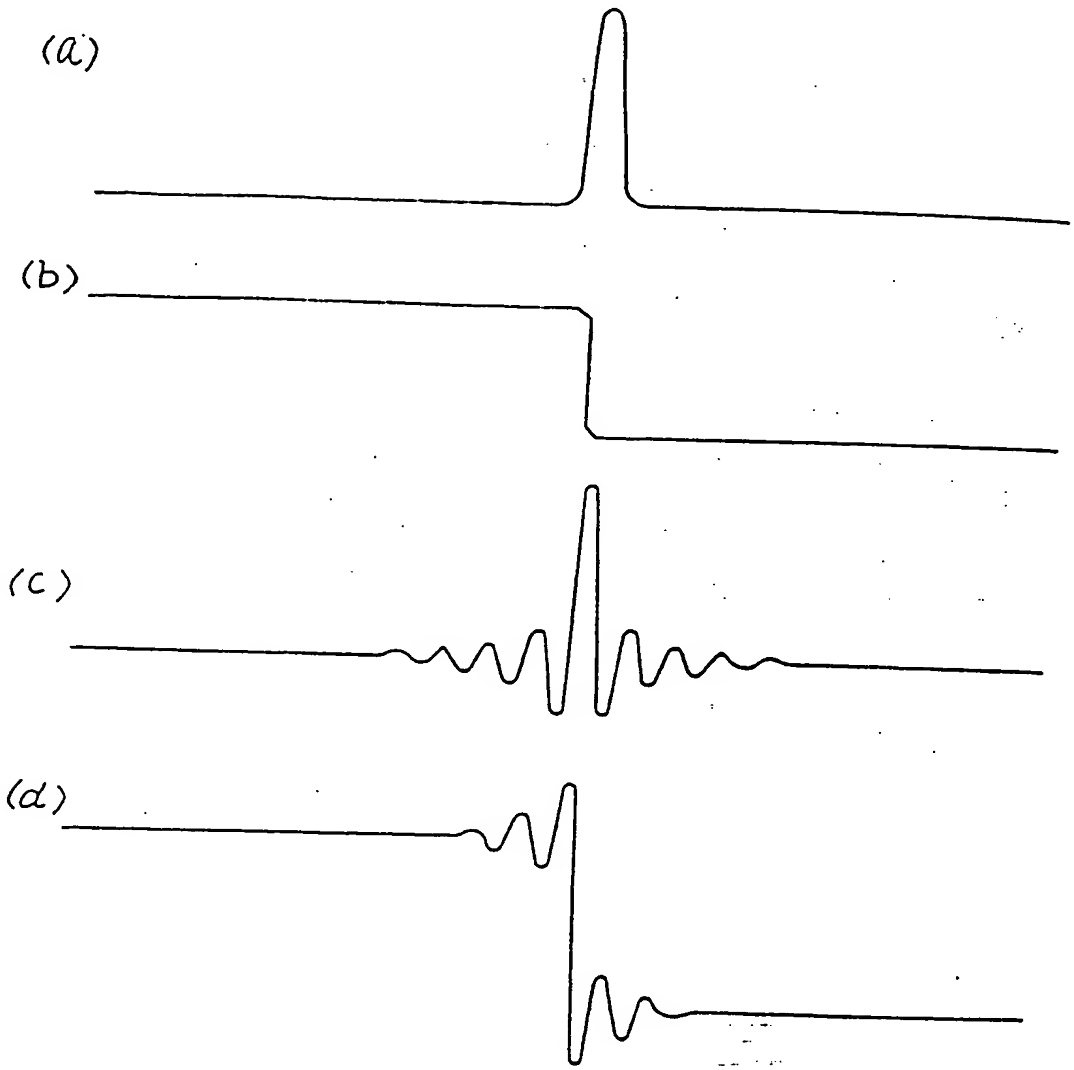


FIG. 28

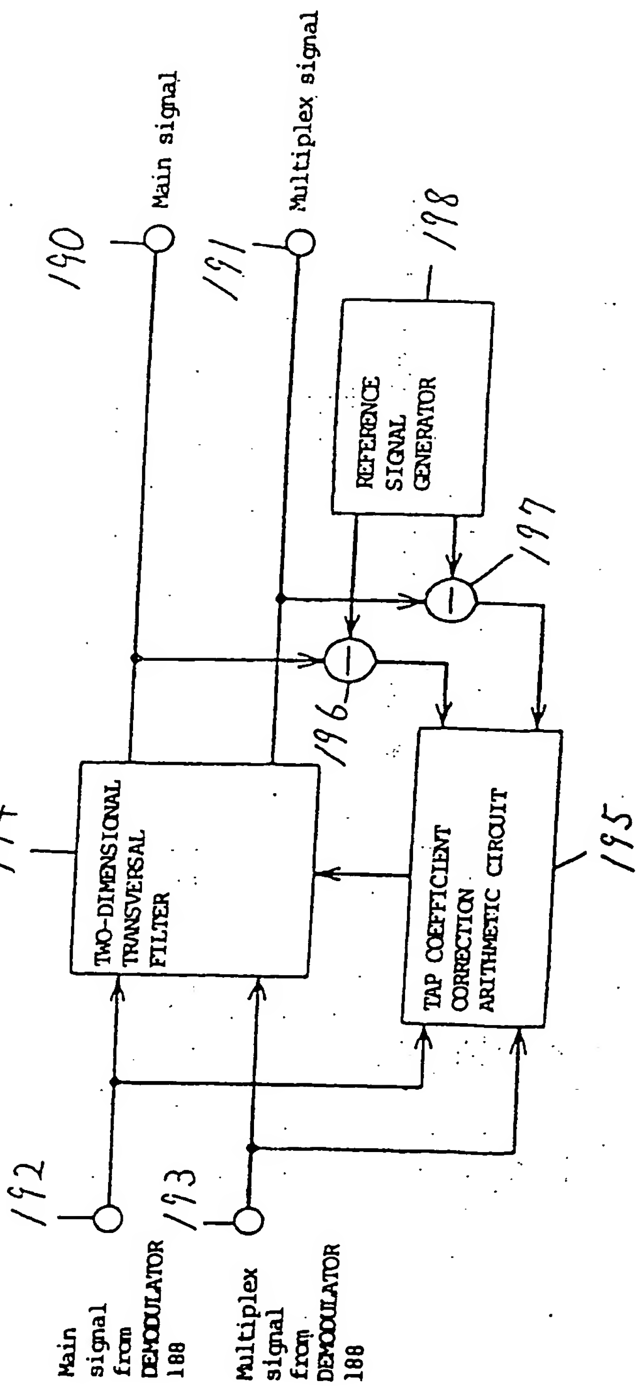

Main signal
Multiplex signal
190
191
198
REFERENCE SIGNAL GENERATOR
197
196
TWO-DIMENSIONAL TRANSVERSAL FILTER
194
TAP COEFFICIENT CORRECTION ARITHMETIC CIRCUIT
195
192
193
Main signal from DEMODULATOR 188
Multiplex signal from DEMODULATOR 188

FIG.29

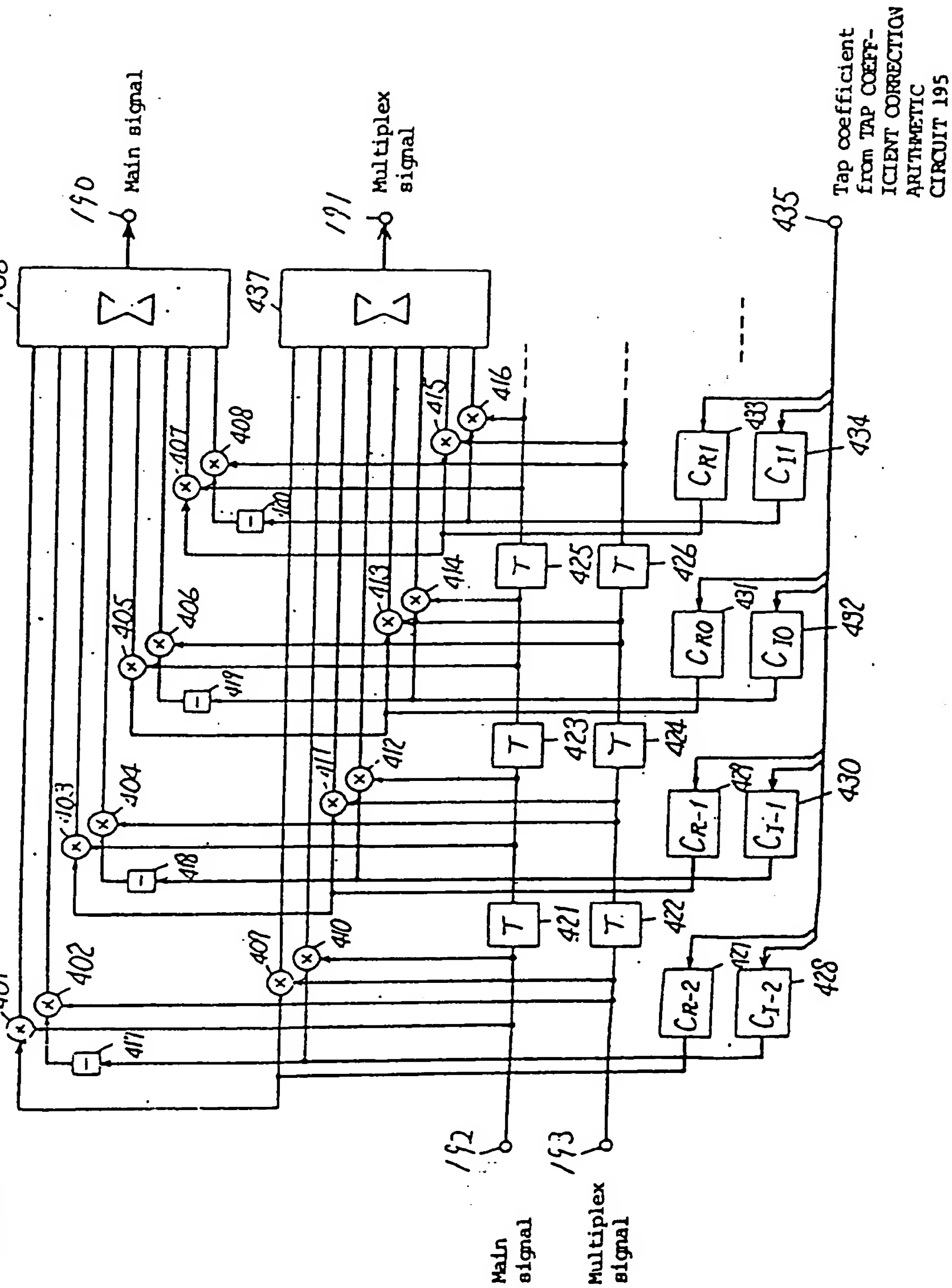

Main signal
Multiplex signal
Tap coefficient from TAP COEFF-ICIENT CORRECTION ARITHMETIC CIRCUIT 195
Main signal
Multiplex signal
190
191
192
193
435
436
437
T
C_{R1}
C_{I1}
C_{R0}
C_{I0}
C_{R-1}
C_{I-1}
C_{R-2}
C_{I-2}

FIG.30

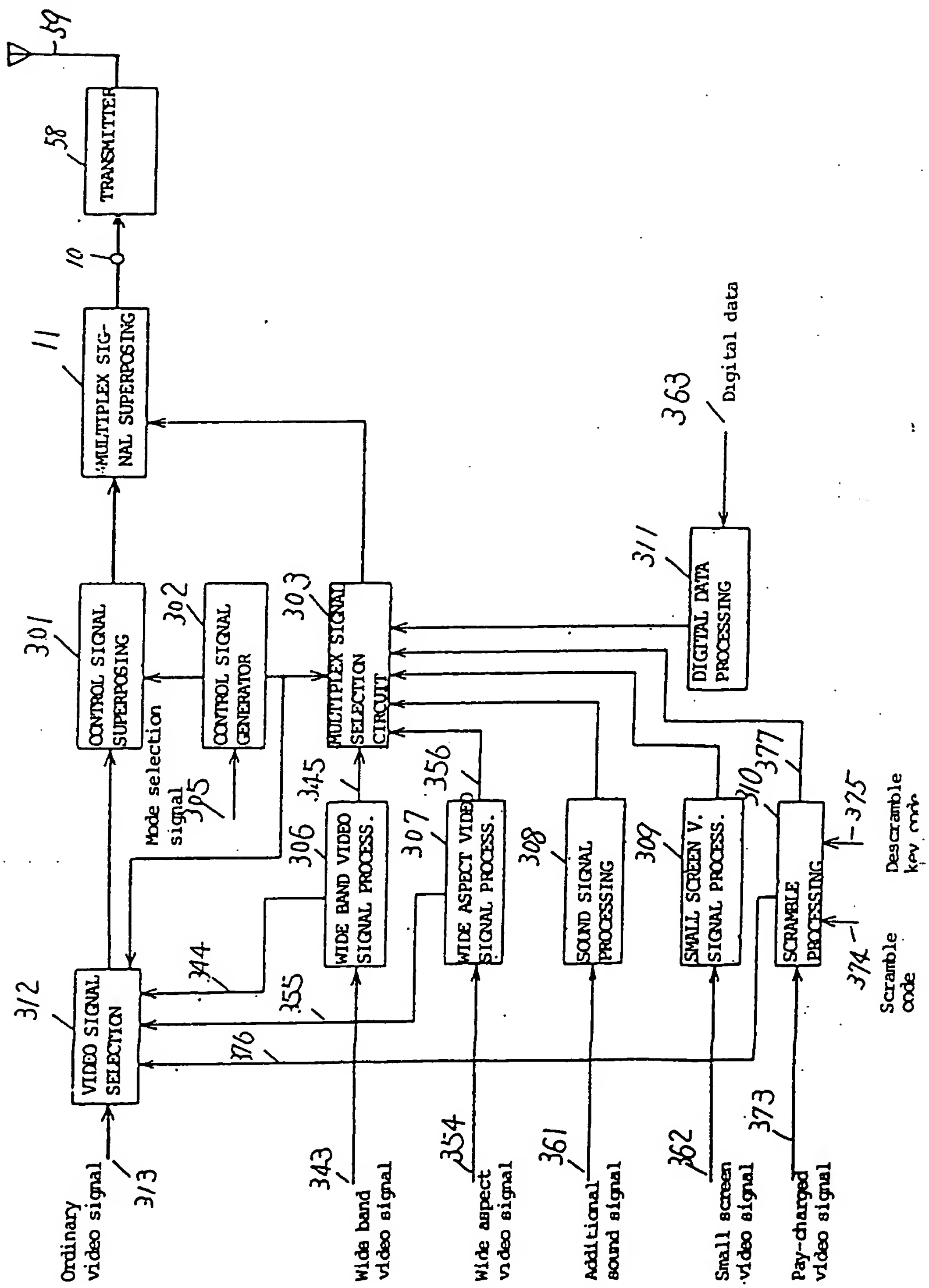

TRANSMITTER
MULTIPLEX SIGNAL SUPERPOSING
CONTROL SIGNAL SUPERPOSING
CONTROL SIGNAL GENERATOR
MULTIPLEX SIGNAL SELECTION CIRCUIT
DIGITAL DATA PROCESSING
Digital data
VIDEO SIGNAL SELECTION
WIDE BAND VIDEO SIGNAL PROCESS.
WIDE ASPECT VIDEO SIGNAL PROCESS.
SOUND SIGNAL PROCESSING
SMALL SCREEN V. SIGNAL PROCESS.
SCRAMBLE PROCESSING
Mode selection signal
Descramble key code
Scramble code
Ordinary video signal
Wide band video signal
Wide aspect video signal
Additional sound signal
Small screen video signal
Pay-charged video signal
59
58
10
11
301
302
303
305
306
307
308
309
310
311
312
313
343
344
345
354
355
356
361
362
363
373
374
375
376
377

FIG.31

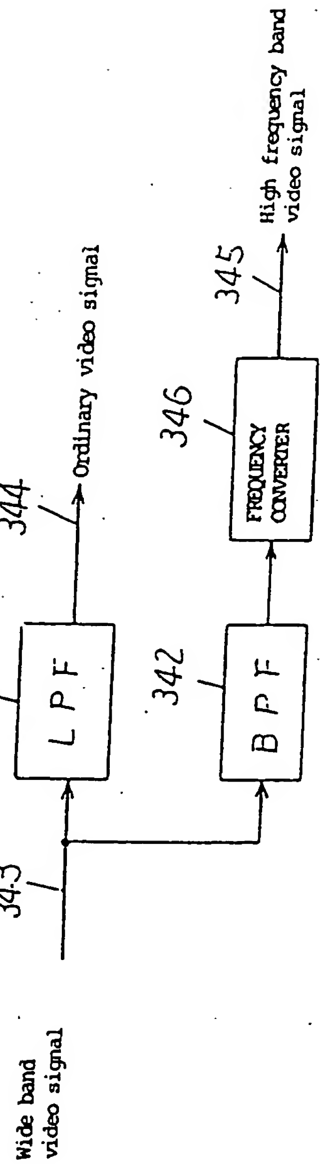

Wide band video signal
343
341
L P F
342
B P F
344
Ordinary video signal
346
FREQUENCY CONVERTER
345
High frequency band video signal

FIG.32

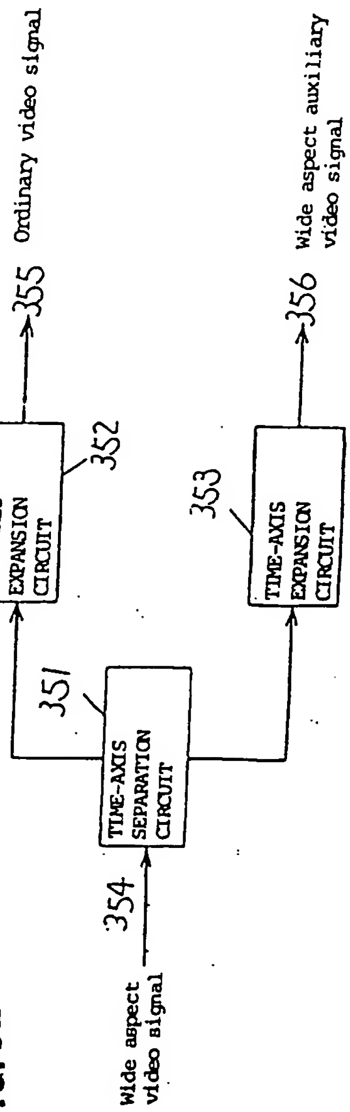

Wide aspect video signal
354
351
TIME-AXIS SEPARATION CIRCUIT
352
TIME-AXIS EXPANSION CIRCUIT
353
TIME-AXIS EXPANSION CIRCUIT
355
Ordinary video signal
356
Wide aspect auxiliary video signal

FIG. 33

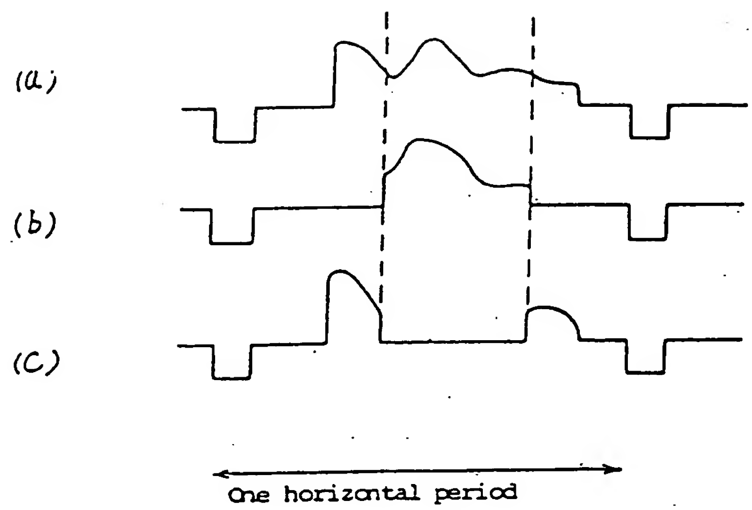
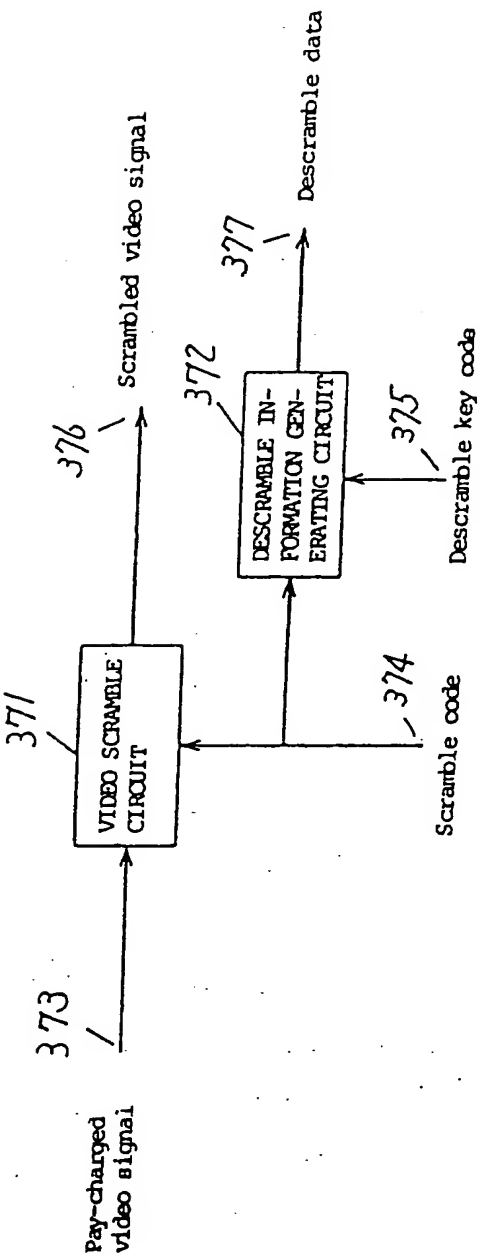


FIG.34


Pay-charged video signal
373
VIDEO SCRAMBLE CIRCUIT
371
Scramble code
374
DESCRAMBLE INFORMATION GENERATING CIRCUIT
372
Descramble key code
375
376
Scrambled video signal
377
Descramble data

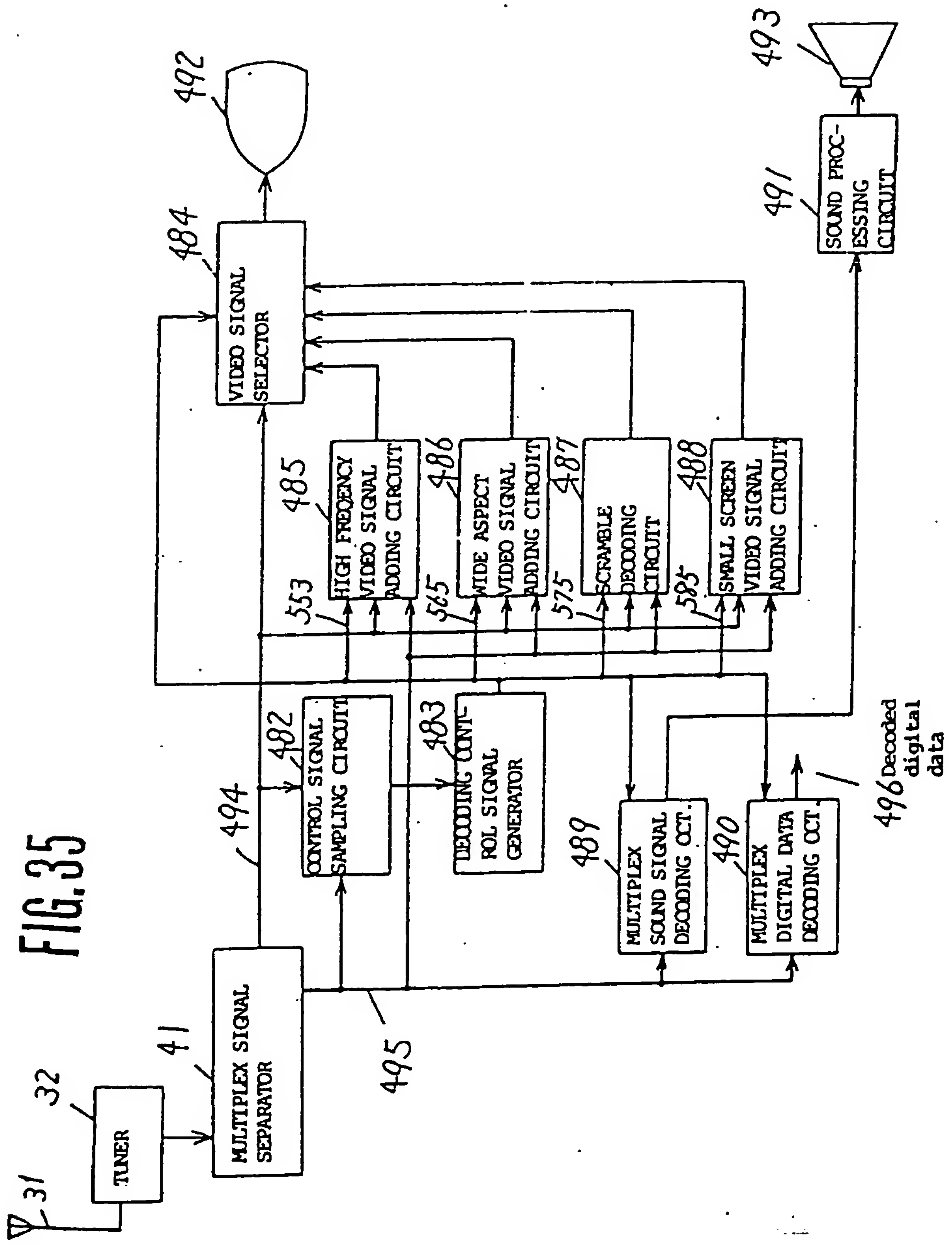

31
32
TUNER
41
MULTIPLEX SIGNAL SEPARATOR
494
495
482
CONTROL SIGNAL SAMPLING CIRCUIT
483
DECODING CONTROL SIGNAL GENERATOR
484
VIDEO SIGNAL SELECTOR
492
485
HIGH FREQENCY VIDEO SIGNAL ADDING CIRCUIT
553
486
WIDE ASPECT VIDEO SIGNAL ADDING CIRCUIT
565
487
SCRAMBLE DECODING CIRCUIT
575
488
SMALL SCREEN VIDEO SIGNAL ADDING CIRCUIT
585
489
MULTIPLEX SOUND SIGNAL DECODING CCT.
490
MULTIPLEX DIGITAL DATA DECODING CCT.
496
Decoded digital data
491
SOUND PROCESSING CIRCUIT
493

FIG.35

FIG.36

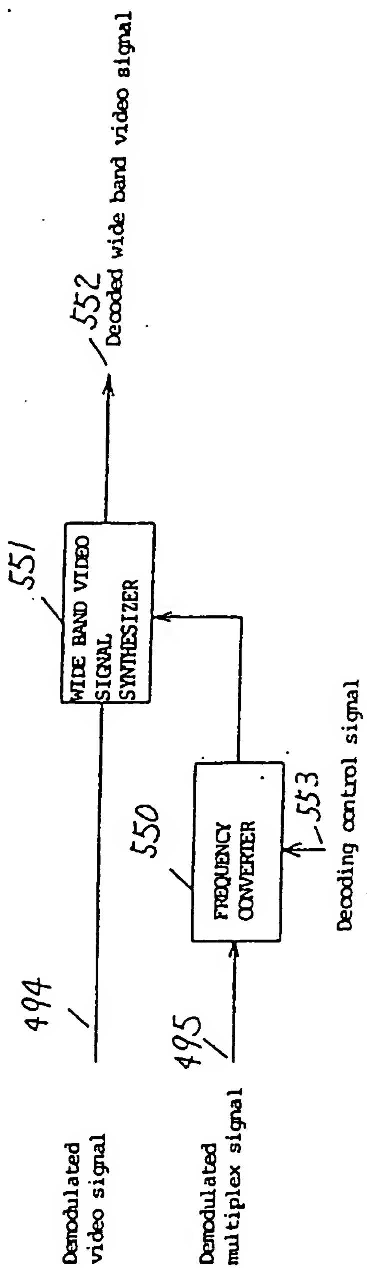

Decoded wide band video signal
552
551
WIDE BAND VIDEO SIGNAL SYNTHESIZER
550
FREQUENCY CONVERTER
553
Decoding control signal
494
495
Demodulated video signal
Demodulated multiplex signal

FIG.37

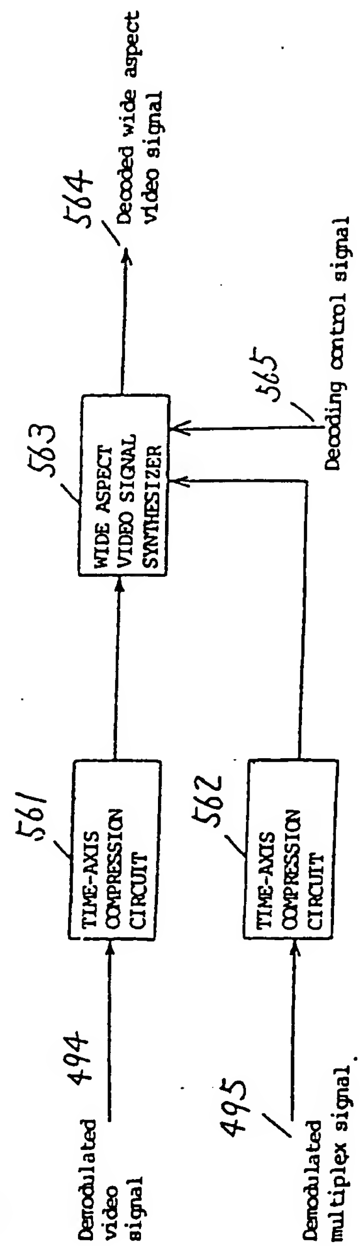

564
Decoded wide aspect video signal
563
WIDE ASPECT VIDEO SIGNAL SYNTHESIZER
565
Decoding control signal
561
TIME-AXIS COMPRESSION CIRCUIT
562
TIME-AXIS COMPRESSION CIRCUIT
494
495
Demodulated video signal
Demodulated multiplex signal

FIG. 38

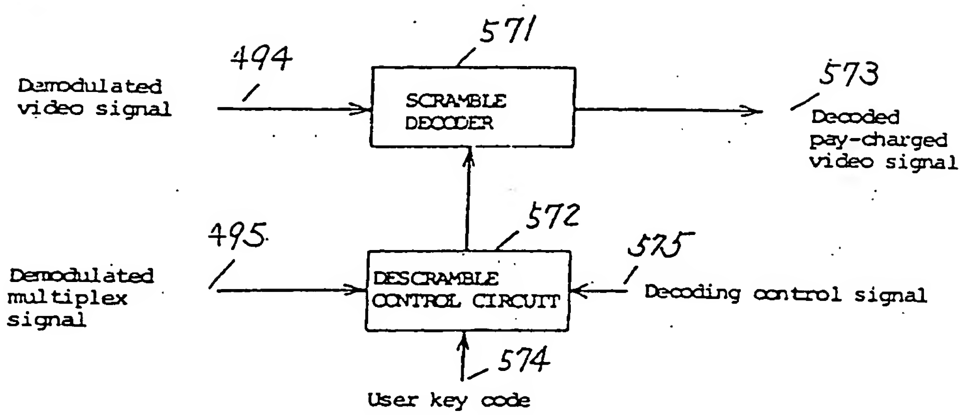

571
494
Demodulated video signal
SCRAMBLE DECODER
573
Decoded pay-charged video signal
572
495
Demodulated multiplex signal
DESCRAMBLE CONTROL CIRCUIT
575
Decoding control signal
574
User key code

FIG. 39

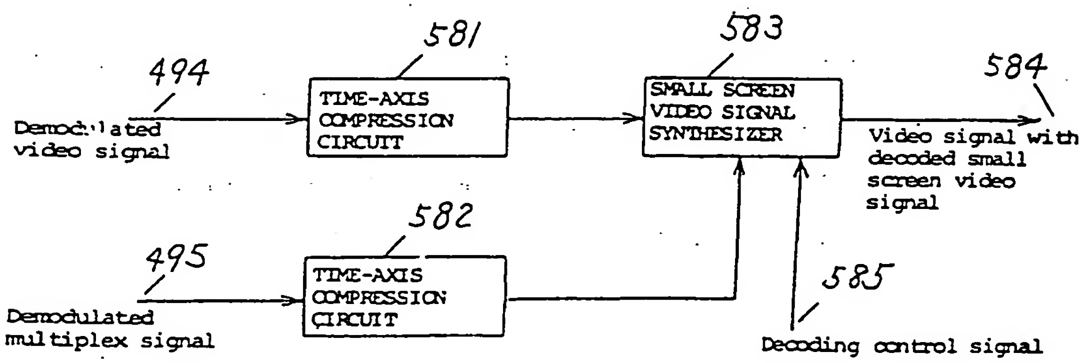
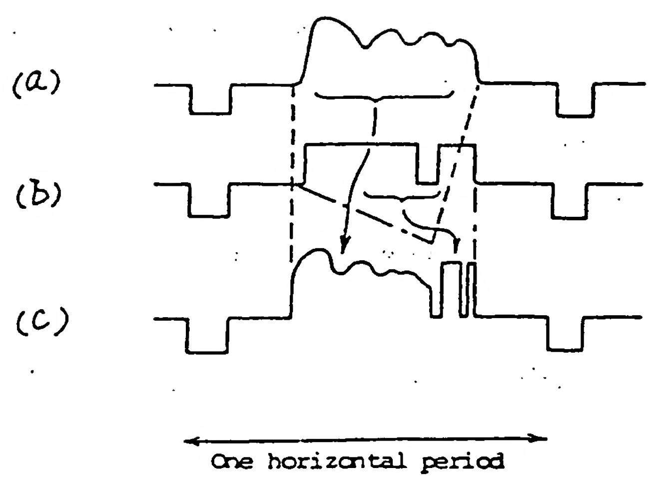

581
583
494
584
Demodulated video signal
TIME-AXIS COMPRESSION CIRCUIT
SMALL SCREEN VIDEO SIGNAL SYNTHESIZER
Video signal with decoded small screen video signal
582
495
TIME-AXIS COMPRESSION CIRCUIT
Demodulated multiplex signal
585
Decoding control signal

FIG.40



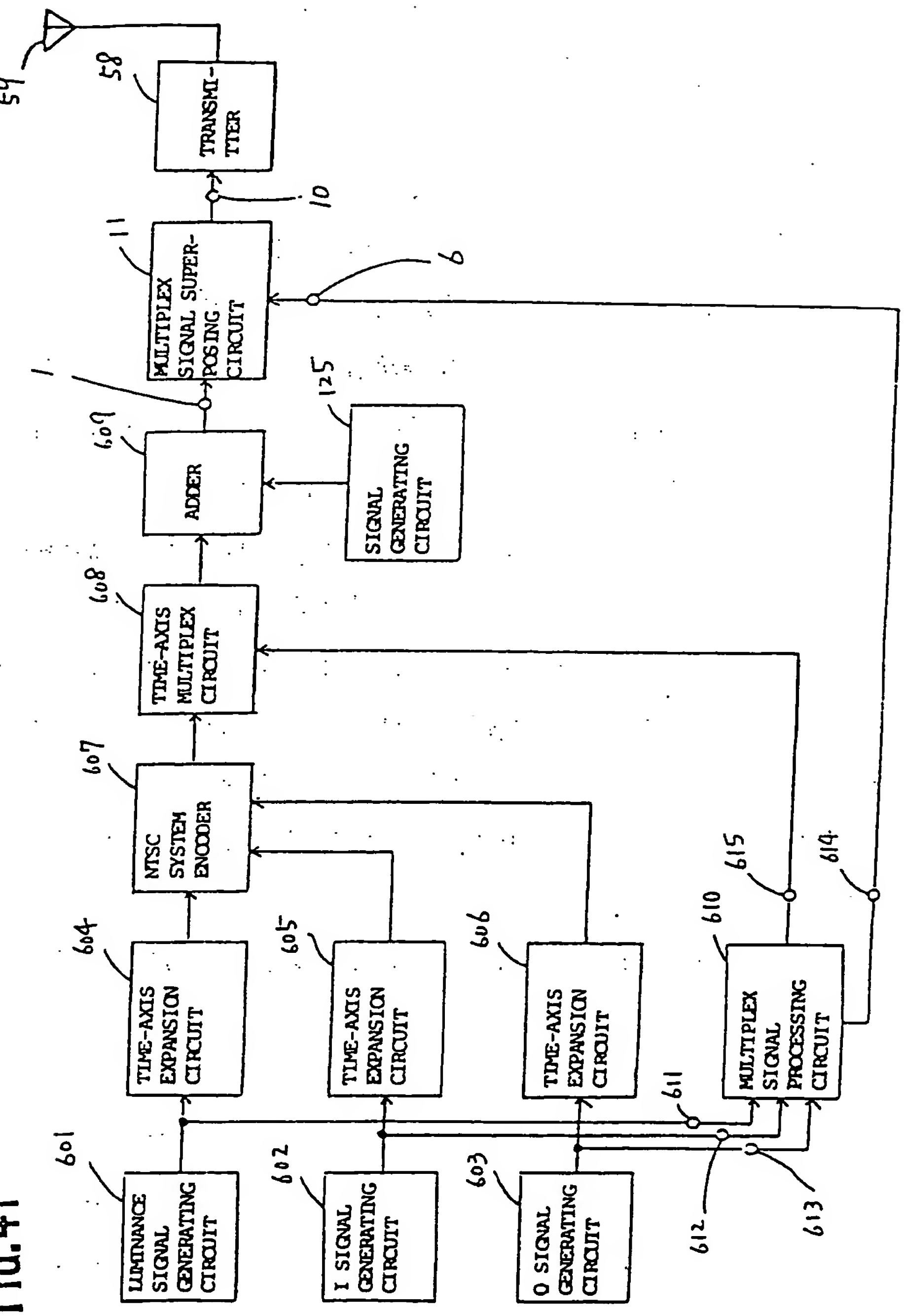

LUMINANCE SIGNAL GENERATING CIRCUIT
I SIGNAL GENERATING CIRCUIT
Q SIGNAL GENERATING CIRCUIT
TIME-AXIS EXPANSION CIRCUIT
TIME-AXIS EXPANSION CIRCUIT
TIME-AXIS EXPANSION CIRCUIT
MULTIPLEX SIGNAL PROCESSING CIRCUIT
NTSC SYSTEM ENCODER
TIME-AXIS MULTIPLEX CIRCUIT
ADDER
SIGNAL GENERATING CIRCUIT
MULTIPLEX SIGNAL SUPER-POSING CIRCUIT
TRANSMI-TTER
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
125
1
6
10
11
58
59

FIG.41

FIG.42

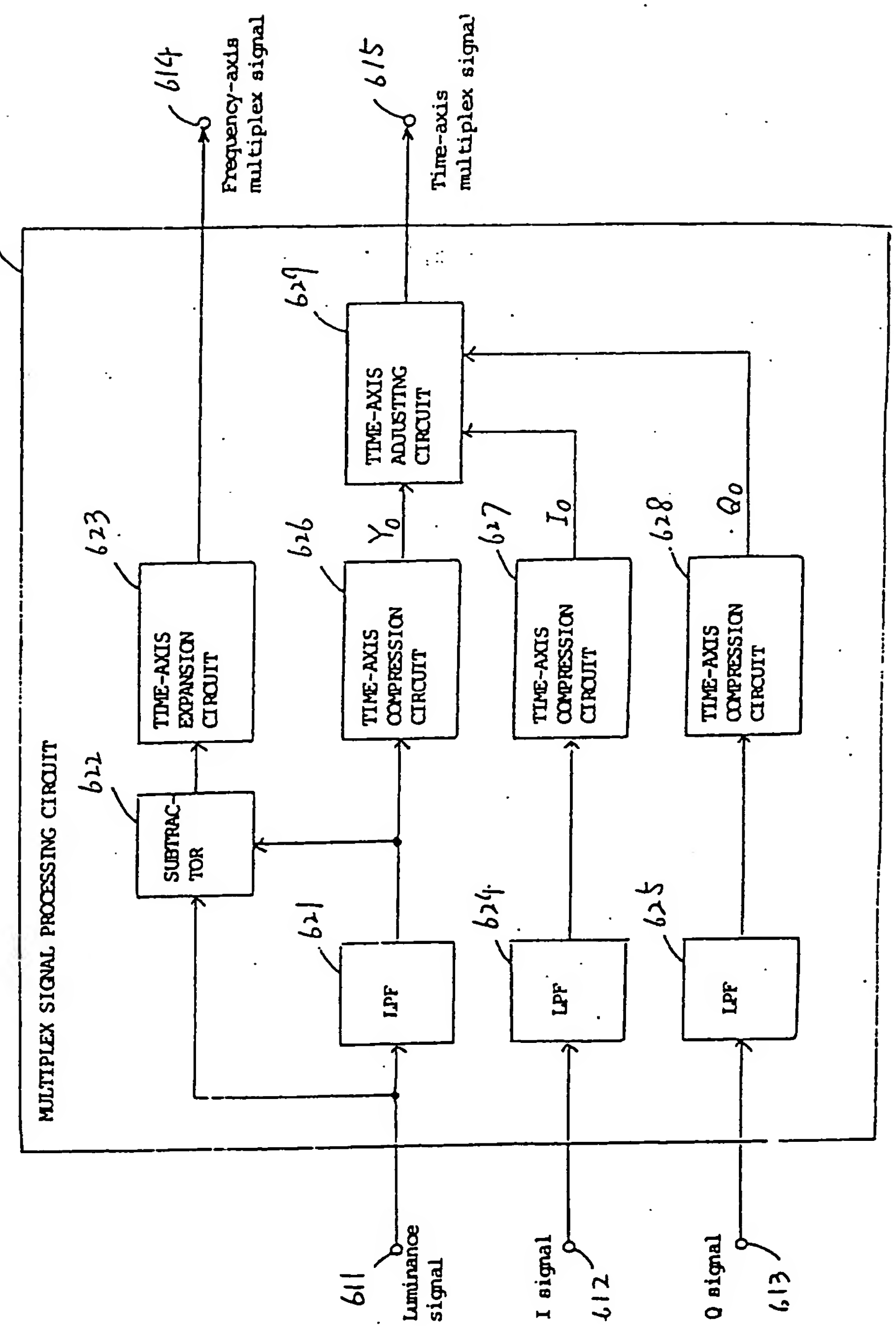

610
MULTIPLEX SIGNAL PROCESSING CIRCUIT
611
Luminance signal
612
I signal
613
Q signal
621
LPF
624
LPF
625
LPF
622
SUBTRACTOR
623
TIME-AXIS EXPANSION CIRCUIT
626
TIME-AXIS COMPRESSION CIRCUIT
627
TIME-AXIS COMPRESSION CIRCUIT
628
TIME-AXIS COMPRESSION CIRCUIT
Yo
Io
Qo
629
TIME-AXIS ADJUSTING CIRCUIT
614
Frequency-axis multiplex signal
615
Time-axis multiplex signal

FIG.43

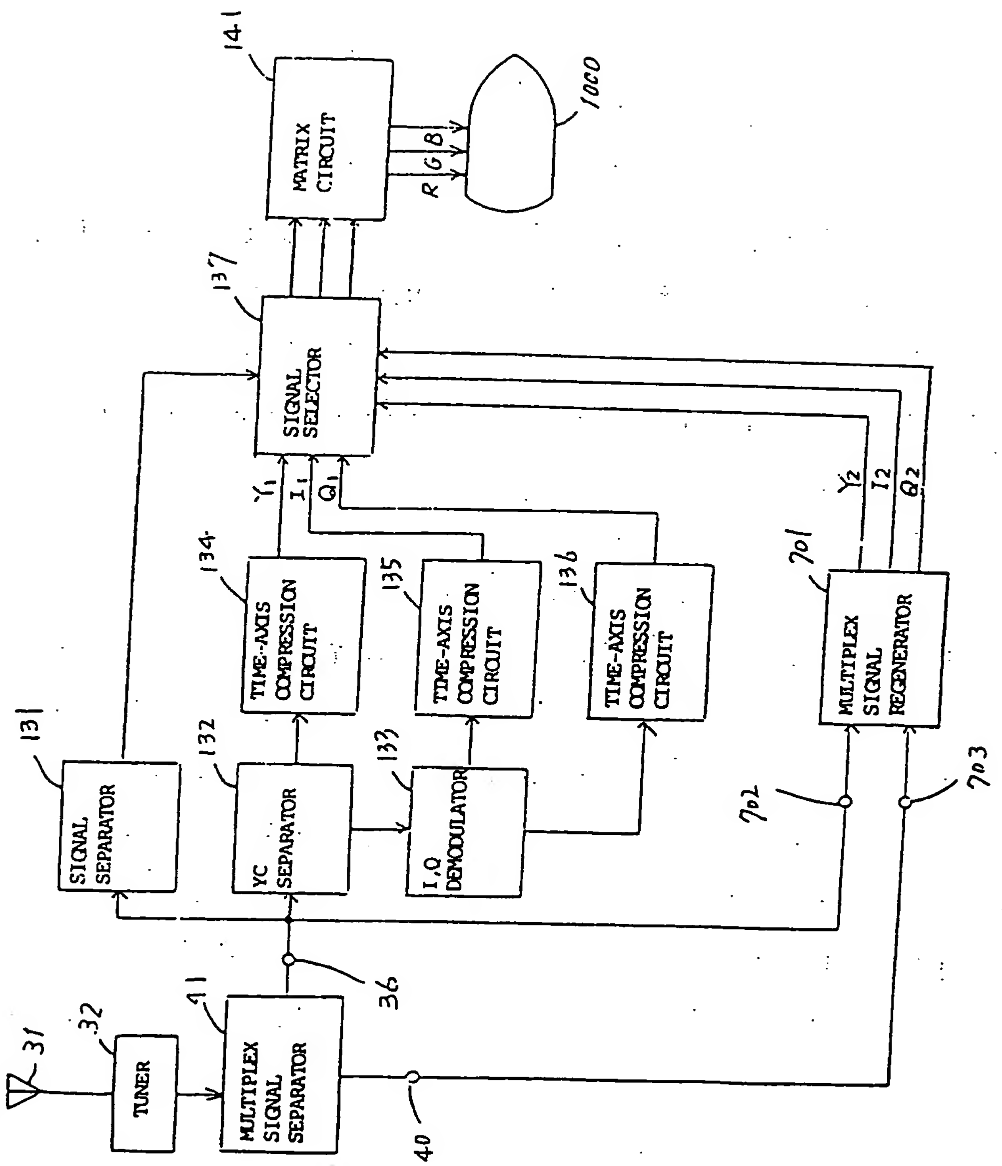
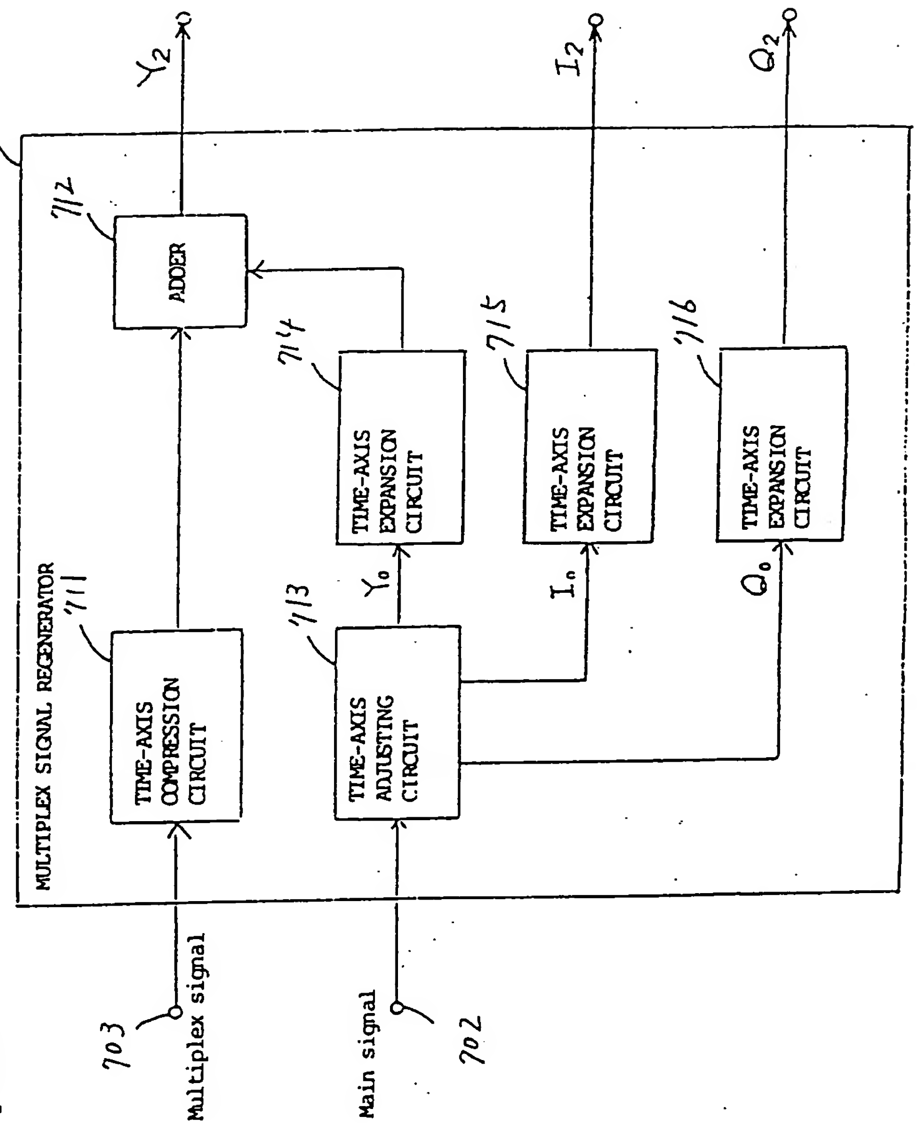

31
32
TUNER
41
MULTIPLEX SIGNAL SEPARATOR
36
40
131
SIGNAL SEPARATOR
132
YC SEPARATOR
133
I,Q DEMODULATOR
134
TIME-AXIS COMPRESSION CIRCUIT
135
TIME-AXIS COMPRESSION CIRCUIT
136
TIME-AXIS COMPRESSION CIRCUIT
Y1
I1
Q1
137
SIGNAL SELECTOR
141
MATRIX CIRCUIT
R
G
B
1000
701
MULTIPLEX SIGNAL REGENERATOR
Y2
I2
Q2
702
703

FIG.44


MULTIPLEX SIGNAL REGENERATOR
701
702
703
Main signal
Multiplex signal
711
TIME-AXIS COMPRESSION CIRCUIT
712
ADDER
713
TIME-AXIS ADJUSTING CIRCUIT
714
TIME-AXIS EXPANSION CIRCUIT
715
TIME-AXIS EXPANSION CIRCUIT
716
TIME-AXIS EXPANSION CIRCUIT
Y_0
I_0
Q_0
Y_2
I_2
Q_2